

**AN INVESTIGATION OF CLIMATE CHANGE AND ITS IMPACT ON HEALTHCARE
PROVISION IN SOUTH AFRICA**

by

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DECLARATION

I, Shelley Cook, declare that “AN INVESTIGATION OF CLIMATE CHANGE AND ITS IMPACT ON HEALTHCARE PROVISION IN SOUTH AFRICA” is my own original work and all the sources used and quoted have been appropriately acknowledged in the complete reference list. I understand what plagiarism is and I am aware of the University’s policy in this regard. This work, in its entirety or in part, has not been submitted for any other degree or examination at the University of South Africa, nor has it been submitted to any other institution or university. I did not refer to work of current or previous students, lecture notes, handbooks or any other study material without proper referencing. I have not allowed anyone to copy any part of my thesis.

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ABSTRACT

Climate change, a reality, a myth, a conspiracy, remains a point of research and concern, specifically with regards to the impact it has on human health. Reports concerning climate change are accepted by many but are also rejected by prominent figures of society and powerful enterprises flourishing in the race for economic development. Yet all living organisms on Earth are dependent on its natural resources and delicate balance of co-existence. A disruption of ecological balance will bring about changes to biomes and niches. These changes will affect disease patterns and well-being for all. Vulnerable groups will be most affected. If these changes have occurred and continue to occur what provision should be made to reduce population vulnerability? What investment should be made to public healthcare to assist vulnerable population groups and improve adaptability? This study was conducted with the aide of the South African Red Cross Society in three large South African provinces, Limpopo, Mpumalanga and Kwa-Zulu Natal, each known for its rich diverse ecologies and tropical to sub-tropical climates. The study aimed to determine the level of awareness amongst the healthcare workers with emphasis on education. The participants were counsellors working closely with the National Department of Health and local clinics. A total of 101 participants completed a close-ended questionnaire. The results indicated a strong workforce of young people with post-matric qualifications and strong views. Qualitative research was used with descriptive statistics to analyse and describe the data collected. It was, therefore, recommended that investment be made into this growing workforce in healthcare, as well as healthcare as a whole, since climate change, as documented, will threaten food security and water availability, see altered diseases patterns including emerging and re-emergence of infectious diseases and cardiovascular concerns brought on by heat stress. Funding must support education and training to strengthen awareness and preparedness so as to empower this workforce so that they may assist local populations to better adapt to the changes, become more resilient and, thereby, reduce their vulnerability and risk.

Keywords: climate change, infectious diseases, human health, public healthcare, early warning systems

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LIST OF ABBREVIATIONS

AR5	IPCC Fifth Assessment Report
C2ES	Centre for Climate and Energy Solutions
COMESA	Common Market for Eastern and Southern Africa
DEA	Department of Environmental Affairs
EAC	East African Community
ENSO	El Nino/Southern Oscillation
GDP	Gross Domestic Product
IHR	International Health Regulations
IMED	International Meeting on Emerging Diseases and Surveillance
IPCC	Intergovernmental Panel on Climate Change
MDGs	Millennium Development Goals
NCCC	National Committee on Climate Change
NCCR	National Climate Change Response
ProMED	Programme for Monitoring Emerging Diseases
SADC	Southern African Development Community
SPM	Summary for Policy Makers
UNDEP	United Nation Department of Environmental Protection
UNESCO	United Nations Educational, Science and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
VBPD	Vector-borne and parasitic diseases
WHA	World Health Authority
WHO	World Health Organisation
WRC	Water Research Commission

CHAPTER 1: THE PROBLEM AND ITS SETTING

1.1 Introduction

“Ironically, the burgeoning economy that the world hopes will eradicate poverty and improve wellbeing for all implies an accelerating increase in global entropy – the destructive disordering of the very ecosystems upon which the entire human enterprise depends” (Rees, 2012: 294)

In 1988, the United Nations Environment Programme (UNEP) and the World Meteorological Organisation (WMO) established the Intergovernmental Panel on Climate Change (IPCC) in order to assess climate change and “provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts” (IPCC, 2014a). Subsequent to its inception, the panel (made up of three working groups) has published five assessment reports. The fifth of which, released in 2014 and published in 2015, has the IPCC’s Working Group I, responsible for reporting on the science of climate change, concluding that climate change is real and is due to mankind’s activities. The report was released shortly after a period of severe weather-related disasters and some of the hottest years on record (UNFCCC, 2014; IPCC, 2014b).

The IPCC has defined climate change as “a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer” (IPCC, 2007a). Succinctly, any change in climate over time. Climate refers to the weather conditions known to an area or region. More specifically, these conditions are long-term weather patterns and include temperature, atmospheric pressure, precipitation, humidity and wind. Long-term change in these conditions or patterns indicates a change in overall climate. A gradual increase in the overall temperature of the earth’s atmosphere is called global warming, a now-known consequence of climate change. Climate change and the related global warming are identified as being anthropogenic – caused or produced by humans – due to activities involved in economic development. The Earth’s natural balance is being disrupted by such activities and the natural processes capable of restoring the balance are being depleted. This is specifically noted in the increase in

greenhouse gases and the resultant greenhouse effect.* As a result, weather extremes such as heavy flooding, severe drought and destructive hurricanes have increased and place strain on existing infrastructure and public health care.

Linking these weather extremes to climate change, the following are noted:

- i. Greenhouse gas concentrations in the atmosphere are directly linked to the average global temperature;
- ii. Greenhouse gas concentrations and the related global temperature have been rising since the start of the Industrial Revolution[†];
- iii. CO₂, the most abundant greenhouse gas, is a product of burning fossil fuels.

(UNFCCC, 2014)

It is important to note, however, that not all members of society accept the reports regarding anthropogenic climate change and the theory behind the reports published by the IPCC. Among these are renowned scientists and prominent individuals. Two such individuals include the late Professor Frederick Seitz, a Physicist and President of the Rockefeller University and United States National Academy of Sciences and Patrick Moore, an ecologist, environmental activist and co-founder of the Green Peace organisation. Both are sceptics of global warming and if such warming is anthropogenic, and have strongly voiced their opinions within the scientific realm (Hevesi, 2008, Greenpeace, 2014). The timeline of climate change, as documented by the American Institute of Physics, also reveals that the US government has been prominent in standing against the discovery and the role industrialised nations have played in climate change. For example, in 1992 the US government blocked calls for serious action to reduce greenhouse gas emissions. In 1997, the Kyoto Protocol was rejected by the US senate and by 2001 the US senate completely detached itself from developing mechanisms to reach the Kyoto targets. In 2005, the US government refused to sign the Kyoto treaty with other industrialised countries (AIP, 2014). The current US administration has changed its previous stance and is taking action to combat climate change and has dedicated resources to understanding and

* Greenhouse gases trap radiation and keep the Earth's temperature within acceptable limits for life. Increase in greenhouse gas concentration means an increase in trapped radiation leading to an increase in surface temperature.

[†] The first Industrial Revolution is documented as beginning in 1760 and continuing to between 1820 and 1840 and brought with it new manufacturing processes and the growth of industries such as coal, iron, railroads and textiles. Together with land clearing greenhouse gas emission accelerated as well as population growth. The second Industrial Revolution (also known as the Technological Revolution) is documented as being between 1870 and 1914 and brought with it the expansion of electricity, petroleum and steel. With improved fertilizers, electricity and public health further population growth was experienced.

reducing carbon emissions, building resilience among the populace (specifically in the health sector), adapting to the change, improving climate literacy and investing in cleaner renewable energy. As a major world leader and a forerunning contributor of emissions, this is an important stance.

Regardless of points of view, it is irrefutable that mankind's activities have changed over the decades and these activities have had an impact on his environment. In addition, activities such as land use change, animal husbandry, deforestation, bush encroachment, destruction and altering of ecosystems, extensive use of pesticides and antibiotics have brought mankind detrimentally closer to his environment and the inhabitants thereof, either directly or indirectly. As a result, altered disease transmission has resulted in viral, bacterial and parasitic infections becoming prominent healthcare risks and challenges[‡].

Whether we accept the concept of climate change, global warming, anthropogenic involvement and out-of-place severe weather conditions or not, we still need to pay attention to our impact on our environment and the effect this may have on healthcare in the event that the theory is true. It may be prudent to establish contingencies now in order to carry us through outbreaks that may take us by surprise.

The South African government has taken note of the reports issued regarding climate change and has presented a National Climate Change Response (NCCR) Green Paper, released in 2010 and a White Paper released in 2011. The Green Paper was published in the Government Gazette by the Department of Environmental Affairs, Notice 1083, for public comment. In both reports, adaptation and mitigation have been recognised and incorporated into policy approaches since the government acknowledges South Africa's vulnerability in terms of its socio-economic and human health situation (a developing economy with a high poverty percentage), the impact of climate change on its agricultural (impacting food security) and the country's water-stressed position (DEA, 2010; DEA, 2011).

[‡] At the time of writing, we were experiencing an Ebola outbreak in parts of Africa claiming over 3,000 lives thus far. The virus is known to reside in at least three species of fruit bat native only to Africa (Willey, 2008: 1001-1006). Contact with these animals – mainly due to habitat invasion and meat consumption – has caused the virus to infect humans and spread.

1.2 Background

The concern of climate change together with environmental awareness entered mainstream discussion in the late 1980s with the discovery of ozone depletion. Focus was initially on reversible forms of pollution but later arose as a mainstream political issue in the 1990s with focus on economic and social policies affecting sustainable development. According to Bodansky (2001: 23, 24), the climate change regime can be divided into five periods: foundational (scientific concern), agenda-setting (scientific and policy issue; formation of the IPCC), pre-negotiation (government involvement), formal intergovernmental negotiations (formation of the UNFCCC) and post-agreement (leading to the Kyoto Protocol).

The IPCC published its first assessment report in 1990, two years after its inception. By 1995, the second assessment report was published documenting that the greenhouse warming was human-induced. The third and fourth reports were published in 2001 and 2007, respectively. The year 2007 also marked an increase in popular consciousness of climate science, according to the United Nations Framework Convention on Climate Change (UNFCCC, 2014). The fifth assessment report was available in 2014 and first published in 2015. The IPCC currently has 195 member countries.

The United Nations Framework Convention on Climate Change was established in 1992 from a conference in Rio de Janeiro held by the United Nations Conference on Environment and Development (UNCED) (UNFCCC, 2014). This was an international treaty through which participating countries could cooperatively consider what could be done to limit the increase in global temperature and, thereby, climate change. This formed part of the intergovernmental negotiations period. By 1995, it was determined that measures previously implemented were inadequate. Negotiations led to the adoption of the Kyoto Protocol in 1997. The protocol, still in existence but not completely ratified, legally binds developed countries to reach their emission reduction targets - currently 37 industrialised countries participate.

Despite the efforts, economic development activities and continued industrial processes which result in high emission output continue and are driving mankind, according to some, into an Anthropocene period or epoch, succeeding the Holocene epoch[§] (McMichael: 2013, 2014).

[§] **Holocene:** geologic time representing a period that covers the last 11,700 years of the Earth's history.

Anthropocene: unofficial interval of geologic time that characterises a time in which mankind's collective activities began to alter the Earth's surface, atmosphere, oceans and natural systems such as nutrient cycling. (Encyclopaedia Britannica)

Natural cycles are being disturbed due to these activities and an increase in globalisation ** is leading to damaging environmental changes (McMichael, 2014). The hydrological (water) cycle is being accelerated by warming; evaporation from the earth's surface is increasing in warmer atmospheres and leading to intense downpours and extreme meteorological events (IPCC, 2014b; Epstein, 2002). Nitrogen and phosphorus cycles are being distorted due to land use changes leading to excess quantities of nitrogen and phosphorus entering natural systems; as a result, eutrophication of local dams and ponds is providing a perfect breeding ground for algae and human pathogens reducing the amount of natural drinkable water available and increasing the costs of purifying the water (McMichael, 2014; WRC, 2014). Land use and land degradation, reduction in soil fertility, loss of biodiversity and damage to established ecosystems are more examples of the environmental changes witnessed and experienced over the past 70 years. Resultantly, greenhouse gas emissions have increased due to “dirty” energy demand from fossil fuels in pursuit of economic development.

It is known that greenhouse gases form an essential part of the very important balance of life on Earth. These gases, present in our atmosphere, allow the entrance of visible and ultraviolet light from the Sun and absorb the infrared radiation reflected from the Earth. This serves to prevent the Sun's energy (heat) from escaping into space and increases the temperature on Earth's surface. The primary greenhouse gases are water vapour, carbon dioxide, methane, nitrous oxide and ozone. However, since the Industrial Revolution (pre-industrial), aforementioned anthropogenic activities, with the increase in burning fossil (carbon-based) fuels such as wood, coal and oil, have increased the concentration of atmospheric carbon dioxide (CO₂) by 40% (Think GlobalGreen, 2008; IPCC, 2014b). This amount of atmospheric CO₂ exceeds the removal ability of the natural terrestrial and oceanic sinks (IPCC: 2014b, 2007a; McMichael, 2008). It is noted by the IPCC fifth assessment report (AR5) summary for policy makers (SPM) that about 30% of atmospheric CO₂ has been absorbed by the oceans leading to acidification (IPCC, 2014b). It is noted, through environmental consciousness and news reports, that these natural sinks, specifically terrestrial (trees and vegetation), have themselves been diminished by mankind's industrialised activities of land clearing required to sustain changes in land use and agriculture. The increase in atmospheric CO₂ and other greenhouse gases intensifies the greenhouse effect – more molecules with the ability to trap

** **Globalisation:** Defined by UNESCO as “a set of economic, social, technological, political and cultural structures and process arising from the changing character of the production, consumption and trade of goods and assets that comprise the base of the international political economy” (UNESCO, 2003).

more radiation leading to a net increase in atmospheric temperature and the global warming phenomena. In 2007, the Department of Environmental Affairs reported that greenhouse gas emissions in South Africa had increased between the years 1990 and 1994 with the major contributions coming from the energy sector: 75% in 1990 increasing to 78% in 1994 (DEA, 2007). In 2014, Urban Earth reported that greenhouse gas emissions have increased 10% in 10 years – 2000 to 2010 – reflecting the figures from the latest draft of the National Greenhouse Gas Inventory. The energy sector's contribution has increased to 85% in 2010. It is also reported that emissions from solid waste disposal has increased by 72% over the same 10 year period (Urban Earth, 2014).

In the 1980s global environmental issues were a growing concern with focus on ozone depletion, deforestation, biodiversity loss, pollution and international trading of hazardous wastes (Bodansky, 2001: 27). Discussion of the concern was initiated within the scientific community and understandably so since all biological systems exist within defined environmental parameters for optimal growth and development. These parameters include temperature and humidity, *inter alia*. Biological systems will adapt according to any environmental change that affects these parameters, either by mutating or shifting geographically (Ostfeld, 2009), in order to maintain the optimal conditions for growth and reproduction. Some organisms, such as arthropods, are highly dependent on temperature as they cannot regulate their own body temperature while others rely on precipitation to create good breeding sites (Patz *et al*, 2005). The slightest change in their environment will dramatically change their habits and behaviour. In insects, an increase in temperature increases larval development as well as adult activities leading to increased frequency of meals and opportunities for reproduction (Githeko, 2009). In addition, many insects are important vectors for infectious disease agents. The female *Anopheles* mosquito, for example, is the vector for the malaria-causing protozoan, *Plasmodium falciparum* and the Tsetse fly, *Glossina palpalis*, is the vector for the disease-causing protozoan *Trypanosoma brucei*. Insects and other animals will move into more habitable areas if changes to their existing habitats necessitate it. Such movement of vectors and animal hosts will change disease patterns and will result in increased risk to human health. Merging economic development activities which bring mankind closer to “wild” territory with changed insect / animal patterns and behaviour, it is easy to appreciate the potential risk of contracting infectious diseases not previously endemic and then promoting their proliferation by increased human movement and contact.

Public awareness and preparedness will go far in curbing the possibility of climate-induced emergence and re-emergence of infectious diseases. Emphasis must, therefore, be placed on environmental and public immunology, public healthcare provision, a strong epidemiology radar and the role these play in communities that are most vulnerable and most at risk. How can we improve resilience? How can we forge adaptation in remote areas? How will we improve healthcare provision in order to prevent a tipping point for public health? These concerns are identified by the South African government and form part of the mitigation and adaptation responses outlined in both the NCCR Green Paper and the NCCR White Paper. It is acknowledged that vector-borne diseases such as malaria and schistosomiasis, together with the lesser known Rift Valley Fever, are “an ever-present reality”. Any changes in weather patterns will have a significant impact on the vulnerable sector of society burdened by disease and aggravate the existing level of poverty, food insecurity and societal imbalances (DEA, 2010; DEA, 2011).

It is time to start budgeting for an anticipatory problem, invest in education within healthcare and create better insight on epidemiology amongst nursing staff.

1.3 Problem Statement

An investigation of the impact of climate change and its potential effect on vector-borne infectious disease patterns and healthcare provision in South Africa with the aim of creating public healthcare awareness and preparedness, to nurture a culture of sustainable prevention and preservation. An investigation that engages the aide of opinions received from field healthcare workers and members of the South African Red Cross Society and is an analysis of perceptions will contribute to such awareness and preparedness.

In order to achieve the intention to build a better life for all and ensure access to health services public primary healthcare workers and community members must be aware of current and future risks to human health, especially those driven by climatic and environmental changes. The South African constitution commits to “improve the quality of life for all citizens and free the potential of each person”. The constitution’s Bill of Rights states that everyone has the right

to life and to have their dignity respected and protected. The Human Rights Commission was established to protect these human rights by promoting respect for them. The Commission, therefore, has the power to investigate, report, research and educate where human rights are not being protected and respected (Constitution of the Republic of South Africa, 1996). The principles set out in the NCCR White Paper and Green Paper are guided by the Constitution and the Bill of Rights (DEA, 2011).

Climatic and environmental changes have been attributed to anthropogenic activities, human related activities generally centred on economic development, leading one to believe that there is no immediate fix or reversal of events. It is to be expected that all members of society will be affected by these climate changes, some more notably than others. The measure of survival success will depend on where on the scale the population lies with regards to vulnerability and adaptability (McMichael, 2001b). Of the many effects change in climate can exert on human health disease transmission is of significant importance. Early warning systems (EWS) and predictive models, in order to detect early infections, are becoming increasingly important in limiting disease severity and duration, thereby preventing potential outbreaks and epidemics. International literature exhaustively discusses learning from the past and applying to the future, setting up models and attempting to influence decision- and policy makers to focus on public healthcare initiatives and funding in order that these may have the required management tools in place to cope with disease outbreaks and prevent an epidemic (Grasso *et al*, 2012; McMichael, 2004; Patz *et al*, 2003; McMichael *et al*, 2006; Patz *et al*, 2005).

Education is a powerful tool to ensure preparedness and a tool of this nature is best in the hands of healthcare workers who mostly have a respectable position within any community. Naturally, a realistic EWS and/or predictive model/s must be in place. In the meantime, public healthcare practitioners and thereby communities must be educated and enlightened. Improving healthcare naturally impacts on other areas of the Millennium Development Goals^{††} focus such as preserving biodiversity and the environment, reducing the burden of disease, poverty and the economic strain. Education and awareness programmes are underpinned by the

^{††} **Millennium Development Goals:** : 1) Eradicate extreme poverty and hunger 2) Achieve universal primary education 3) Promote gender equality and empower women 4) Reduce child mortality 5) Improve maternal health 6) Combat HIV/AIDS, malaria and other diseases 7) Ensure environmental sustainability 8) Develop a global partnership for development (UNDP, 2012).

South African government in the response strategy and adaptation policies to climate change (DEA, 2010; DEA 2011).

Research Problem

Exogenous factors play a crucial role in the survival of both macro and microorganisms, specifically on those that are so dependent on them – such as insects and parasites which lack the ability to regulate their own temperature and seek out an environment conducive to their successful survival (Ostfeld, 2009; Patz *et al*, 2003). Climate, and thereby, temperature, humidity and rainfall, have a great impact on the development and reproductive rates of insects (especially significant when these play the role of vector to infectious disease agents) and parasites (Githeko 2009). Feeding needs and habits change with increased ambient temperature usually resulting in increased activity, metabolism, need for food and ultimately opportunities for reproduction. Vectors and parasites are opportunists, known to jump species if that satisfies the basic concepts of survival (Altizer *et al* 2013). Global travel has opened up a gateway and made transmission and movement of these organisms more real and possible (Morens *et al*, 2004; McMichael, 2004). These anthropogenic movements also relate to economic growth and development (often plain survival) which have bush encroachment and land use changes as their flag ships sailing into areas inhabited by vectors, parasites, bacteria and viruses constrained by natural elements and animals (McMichael, 2011).

Much has been written on the link between human health and climate change. Many learned academics specialise in the field – on a humanitarian and economic level. Extensive research has been conducted to determine the global impact, provide figures and percentages, and engage world leaders in bringing about change and correction. This has been done via the Kyoto Protocol, the Intergovernmental Panel on Climate Change (IPCC), the Convention of Parties with its United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Environmental Programme (UNEP). Specific emphasis has been placed on the burning and use of fossil fuels versus alternative energy sources – such as bioenergy (preferred) and nuclear energy. Yet, as noted by the findings of the Africa Talks Climate research the public know very little of what is going on around them in terms of their environment and the threat man's economic development activities is having on it.

Magnifying the relationship between climate change and infectious disease distribution and transmission patterns with a view to adding insight into potential future events and ensuring that we realize the importance of starting to prepare now for what may occur specifically in terms of public healthcare adaptation is not a new topic but one that is not being taken seriously enough by society. It has been established that Africa is vulnerable and South Africa is included in this assessment (Davies *et al*, 2010; Patz *et al*, 2005; Hulme *et al*, 2004), both to the effects of climate change and the added risk of infectious diseases. It has also been established that African populations do not fully appreciate the extent of the effects on them or their environment (BBC WST, 2010). It is also a growing concern that the Millennium Development Goals from 2009 have not been sufficiently realised and what little progress has been made may be reversed due to the continuing changes in climate and burden of disease (Rao *et al*, 2010). Health promotion has not been given the required attention and funding to assist those most in need and there is a general disconnect between health, social activities and the importance of effective health promotion systems (Sanders *et al*, 2008). Africa Talks Climate emphasised the important role played by the media and how their role can be harnessed to drive information through to the public to generate greater social awareness (BBC WST, 2010). In addition, the media may deter social distancing by influencing public perception before or during an outbreak and provide valuable information which could curb an outbreak (Mummert and Weiss, 2013).

The lifestyle gap between rural and urban communities is great. Rural communities rely almost completely on their environment for survival and are severely affected by environmental changes. Urban communities are reliant on production and are therefore indirectly affected by environmental change. Survival means of these groups are polarised. Day to day survival requirements are so different for people in different parts of the world, particularly when faced with pending economic instability, conflict, food insecurity and disease. Yet, all are affected by change in climate – especially when the optimum conditions gradually alter and place pressure on biological systems. The understanding of climate change amongst the public varies worldwide, but the science behind it is understood only by the minority. Many do not feel responsible for the change in climate and will accordingly not change their behaviour while others tend to be at the mercy of the change in climate considering it unusual weather patterns and relying on God to assist (Pidgion, 2010; BBC WST, 2010).

Articles and books are not available to a large portion of South African communities specifically those in the healthcare sector. Research to determine the knowledge base of healthcare workers with specific reference to climate change and infectious disease patterns will provide direction on how to assist them in promoting healthcare in their area or region. It is important, then, to hear from individuals working in healthcare clinics (subsidised by the National Department of Health and who assist with counselling either HIV/AIDS patients or those wanting to know their status) their opinions and assess their knowledge relating to the impact of climate on disease patterns and how this change will affect their service to their communities. These healthcare workers are situated in the local clinics within the local communities with a strong presence in Limpopo, Mpumalanga and Kwa-Zulu Natal. Healthcare workers for this study relate specifically to members of the South African Red Cross who provide counselling to the patients attending the clinic and other healthcare activities as required.

1.4 Significance of the study

The problems that may result from change in climate and weather on human and environmental health provide sufficient reason to investigate the impact the changes may have on healthcare provision in South Africa and determine the level of awareness among the healthcare workers.

Our current public health care system is finding it difficult to cope with current challenges, inferring that it may not be able to deal with any further risk. However, another viewpoint is that South Africans tend to have the ability to deal with big issues when required.

1.5 Aims and Objectives

The aim of this research, then, is to investigate the impact of climate change and infectious diseases on healthcare provision in South Africa. To achieve this aim, the following objectives should be achieved:

- To obtain opinions and perceptions of primary healthcare workers regarding climate change and its impact on changing disease patterns;
- To synthesise the results of this research so as to recommend appropriate action to improve service provision by healthcare workers in South Africa;

1.6 Hypothesis

H1: Training should be provided to healthcare workers as there is insufficient knowledge among such staff regarding changing disease patterns resulting from the effects of climate change

H0: Training should not be provided to healthcare workers as there is sufficient knowledge among such staff regarding changing disease patterns resulting from the effects of climate change

1.7 Delimitations

Strengths of using questionnaires for qualitative research:

- Issues can be identified and examined;
- The research framework and direction can be revised in light of new information;
- Data obtained from human experience are more powerful and compelling than quantitative data;
- Certain hidden complexities about the research topic is often discovered that may have been missed by other enquiries;

Responses are collected from relatively few individuals and cannot be generalized to a larger population. However, the findings can be transferred to another setting.

Limitations:

- The research findings can be influenced by the researchers' personal biases and preferences;
- Analysis and interpretation is time consuming – depending on the volume of responses;
- Not as well understood and accepted within the scientific community as quantitative research;
- Responses can be influenced by the presence of the researcher;
- Anonymity and confidentiality can hinder validity when presenting the results;

- Findings are difficult to present in a visual way.

(Anderson, 2010)

1.8 Value of Research

The research will contribute to the existing body of knowledge among healthcare workers by providing insight into current awareness of climate change and infectious diseases in South Africa. It should provide an idea of the perception of what is required to ensure resilience, adaptation and preparedness in healthcare service provision. On a national level, the results obtained will be used to investigate the provisions required in healthcare to cope with the impact climate change will have on human health.

Different schools of thought exist regarding climate change and global warming and this paper is not to challenge these. If climate change affects infectious disease patterns and places pressure on our healthcare system by having to align itself with managing additional known and unknown infectious diseases, research will provide great value as to preparedness and adaptation within healthcare provision. The results of this research should complement the opinions of and the environment experienced by healthcare providers to anticipate remedial measures to be implemented, learning programmes to be rolled out for managers and funding to be sought and made available to optimise healthcare service provision within a dynamic environment.

1.9 Research Design and Methodology

Qualitative research was conducted by means of questionnaires: a close-ended questionnaire was used to obtain perceptions of healthcare workers in local community clinics of climate change and the effect on infectious diseases and healthcare provision.

Three provinces were specifically selected due to their hot humid climate favoured by arthropod vectors. The South African Red Cross Society assisted with the distribution and completion of the questionnaires.

A qualitative analysis of perceptions was derived from the questionnaires with the aim of linking this to healthcare provision requirements.

Qualitative research has been criticized for overusing questionnaires and interviews. However, this type of research does have strengths when conducted properly; see 1.7.

1.10 List of Definitions

Adaptive capacity:	General ability to adjust to potential changes, take advantage of opportunities, and cope with consequences
Anthropocene:	Unofficial interval of geologic time that characterises a time period in which mankind's collective activities began to alter the Earth's surface, atmosphere, oceans and natural systems such as nutrient cycling.
Anthropogenic:	Mankind-induced activities
Climate change:	Change in climate over time, due to either natural variability or anthropogenic activities and incorporates temperature increases, sea level rises, snow and ice depletion and changes in precipitation. Change in the state of the climate that can be identified (by of statistical data) by changes in the mean and/or variability of its properties.
Early warning system:	The provision of timely and effective information, through identifying institutions, that allow individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response.
Emerging infectious diseases:	An infectious disease which has increased in prevalence in the past 20 years and threatens to increase in the near future.
Endemicity:	The quality or state of being endemic, that is prevalent in or native (peculiar) to a particular people or country.
Epidemic:	The occurrence of an illness or health-related event in a community or region that exceeds normal expectancy.

Epidemiology:	The study of diseases – how often they occur in different groups of people and why.
Episystem:	A complex system of interacting biological, environmental, economic and social factors affecting emergence and spread of infectious diseases.
Holocene:	Geologic time representing a period that covers the last 11,700 years of the Earth's history.
Hydrological:	Pertaining to the movement of water in relation to land.
Infectious diseases:	Disorders caused by pathogenic micro-organisms that can be spread directly or indirectly from one person to another.
Reservoir:	A population chronically infested with a causative agent of disease acting as a source of further infection.
Vector:	An organism, typically a biting insect that transmits a disease-causing agent from one animal or plant to another.
Vector-borne diseases:	Diseases that result from an infection transmitted by a vector – mainly a biting arthropod.
Vulnerability:	Level of material resources, effective governance, public health infrastructure, access to effective local information and existing burden of disease.

1.11 Outline of Chapters

In order to address the objectives and satisfy the problem statement, this research dissertation has been structured as follows:

Chapter **one** provides a brief view of climate change awareness over the decades and mankind's involvement therein, together with the importance of research into the impact this will have on healthcare provision in South Africa;

Chapter **two** discusses existing literature on the topic in a review. International literature is expansive with regards to climate change, human health and infectious diseases. However, local material is scanty and needs to be explored;

The focus of chapter **three** is on the research methodology used to gather data for this study and the means employed for interpreting the data.

Chapter **four** discusses the results of the research while chapter **five** describes a series of conclusions and recommendations resulting from this research.

For this research study a select group of primary healthcare workers were asked to respond to a series of questions compiled within a questionnaire to determine their awareness and preparedness regarding features of climate change, changes in disease patterns and their capacity to adjust to such changes.

The responses to these questionnaires should contribute answering the following: Are we prepared for what may come as a result of climate and environmental changes? Are we prepared to make necessary changes?

CHAPTER 2: THE REVIEW OF THE RELATED LITERATURE

2.1 Introduction

The articles and books used for this literature review were selected based on the following four categories:

1. Current and emerging infectious diseases in Africa
2. Climate change, human health, infectious diseases and economic effects
3. Predictive models and early warning systems
4. Public health concerns and initiatives

The focus is on South Africa, yet with human migration one cannot consider South Africa, or the SADC region or sub-Saharan Africa as an isolated unit unaffected by neighbouring states, refugees or tourists. The concern is whether we are able to withstand a new infectious disease brought in by the aforementioned with epidemic potential enhanced by climate change. Is our public health system in a position to cope with a new infectious disease? What does local literature say regarding this? Is awareness being created among the public of the risks climate change may bring? What is the stance of the health sector?

The focus is, as indicated, on the effect climate change has on infectious diseases and their transmission patterns and the impact on healthcare provisions in South Africa. Climate change is said to be one factor of many affecting the incidence of infectious disease transmission. However, the other factors – non-climatic socio-demographic factors - which include human migration, transportation, nutrition, and environmental changes brought on by deforestation, agricultural development, water projects and urbanisation (Grasso *et al* 2012) are all part of economic development and it is economic development that produces the very gases that are impacting so heavily on our atmosphere creating the greenhouse effect and stressing Earth's bio-geo-capacity (McMichael 2014). Therefore, it can be inferred that climate change has the greatest effect on infectious disease transmission and is quite clearly the main focus of attention.

2.2 Literature Review

2.2.1 Introduction

Global climate change has captured the attention of epidemiologists through to economists. This is because the impact of such change spans all sectors from the spread of disease to the loss of income. The main cause of the change has been linked to the steady increase of greenhouse gas emissions into the atmosphere, specifically carbon dioxide (CO₂), due to anthropogenic activities at a rate exceeding the ability of the natural terrestrial and oceanic sinks to remove these gases, resulting in a net increase (IPCC: 2014b; McMichael, 2008; Ostfeld, 2009; McMichael, 2014). According to the World Wildlife Fund the Earth's regenerative and absorptive biocapacity is being exceeded by 1.25 times (McMichael, 2008). Increasing levels of these gases is leading to increases in ambient surface temperature averaging around 0.2°C per decade placing pressure on natural hydrological systems with resultant snow and ice depletion, sea level rises and changes in precipitation. The fifth assessment report expresses medium confidence that this has affected water quality and quantity (IPCC: 2014b). Consequently, biological systems are affected by the increase in temperature and precipitation setting off changes in insect, plant and animal behaviour. These changes relate specifically to reproduction, development, feeding and distribution patterns (McMichael, 2001b; Haines *et al*, 2000; Hulme *et al*, 2004; Patz *et al*, 2003; IPCC: 2014b). Terms such as globalization, the Great Acceleration and Anthropocene geological epoch are being incorporated into the vocabulary of researchers and experts when referring to climate change (McMichael: 2013, 2014; Link, 2007; Githeko and Shiff, 2005). Man is becoming a geological force with the capacity to generate sufficient greenhouse gas emissions to significantly change the lower atmosphere and the functioning of all those living within it. Extreme weather events as a result of these changes such as El Niño / Southern Oscillation (ENSO) are known to trigger disease outbreaks among humans and animals. This can lead to food insecurity, public health burdens, economic hardship, emotional and mental anguish (DEA, 2010). Such an ENSO was experienced in 1997/1998 where 6,228 people in Kampala, Uganda, were affected by cholera and around 80% of the livestock in Somalia and Northern Kenya succumbed to Rift Valley Fever (King, 2004; Hulme *et al*, 2004). Economists note that low-income countries will be hardest hit by climate change due to their close interaction with agriculture and poverty and yet these have contributed the least to the change, often being

victims to exporters of ecological change – industrialised developed nations (IPCC: 2014b; Tol, 2009; Thomas *et al* 2008).

Africa, for example, carries 25% of the world's disease burden with only 1% of the world's economic resources to fund it and 3% of the world's healthcare workers to fight it (Robinson and Clark, 2008). Furthermore, Africa is experiencing a double-disease burden of communicable and non-communicable diseases, such as cardiovascular disease, diabetes, hypertension and obesity. Sub-Saharan Africa is hardest hit by infectious disease maladies as these are closely linked to poverty and socio-economic inequality where the Millennium Development Goals (MDGs) have failed to be realised (Chukwuma, 2012; Dube and Chimbari, 2009; McMichael, 2001b). The South African government acknowledges the “serious and complex health challenges compounded by poor living conditions” and that vector-borne diseases such as malaria, schistosomiasis and Rift Valley Fever may spread due to changes in climate. “The links between the environment, food security and the infectious profiles of communities and regions have been well established (DEA, 2011: 19).

With the many priorities facing African leaders, public healthcare and health promotion are not given the attention needed to build healthier communities. Poverty, uncontrolled urbanisation, gender-based inequality, conflict over resources and land, burden of ill health, lack of access to potable water and civil sanitation along with weak public health services, underfunding and loss of qualified health professionals add to the vulnerability of African communities (Sanders *et al*, 2008; Robinson and Clark, 2008).

Benefits of a slight increase in temperature as a result of climate change have been documented and include the reduction of water stress in plants, the reduction of heating costs and the reduction of cold-related illnesses in warmer, temperate regions from which a great economic output is generated. However, the “gains for the high-income areas of the world exceed losses in the low-income areas” – so, where would the focus be, and should it be of concern? Unfortunately, the impact of climate change is greater in low-income countries, even though their greenhouse gas emissions are lower. These communities are vulnerable and less able to adapt to the changes brought on by climate change since resources are limited and there exist “less capable institutions” (Tol: 2009, 2010)

The following questions are raised by Professor Richard Tol, perhaps directed at the high-income populations that may not be so heavily affected: How much will we pay for a better

climate for our children? How much compensation should we pay for damaging their climate? Can we afford to lose an equivalent of a year of economic growth for a century's worth of climate change? (Tol, 2010). Is Africa prepared for the changes that are to come? Will South Africa improve its healthcare provision to meet up with the challenges identified and documented in the NCCR White Paper: "South Africa will integrate climate change considerations into health sector plans"? (DEA, 2011).

2.2.2 Background

The Intergovernmental Panel on Climate Change (IPCC) has been monitoring global atmospheric temperature for decades and published its first assessment report in 1990. Three workgroups were involved in gathering data and issuing reports. These groups comprise researchers and subject matter experts each focusing on their field of expertise.

Subject matter experts have written much about infectious diseases, using titles such as "Emerging Infectious Diseases: Threats to Human Health and Global Stability, The Perpetual Challenge of Infectious Diseases, Emerging Infectious Diseases in 2012" together with the role of climate change under titles of "Earth as human's habitat: global climate change and the health of the population", "The Health Effects of Climate Change: A Survey of Recent Quantitative Research", "Climate Change and Infectious Diseases in Africa", "Malaria and Climate Change". The current view taken by many of these experts is that climate change has an impact on infectious disease transmission rate and patterns which ultimately affect human health placing stress on existing public health infrastructure.

Local literature linking the three aspects of this study: climate change, infectious diseases and public healthcare, is scanty and data are either unreliable (Econex, 2009) or assessments have not been done at all (Grasso *et al*, 2012; van Hasselt, 2011). The South African government has, however, documented its concern in the NCCR Green Paper of 2010 and the NCCR White Paper of 2011. It is acknowledged that climate change will impact on human health in terms of water scarcity, food insecurity and vector-borne diseases (DEA: 2010, 2011).

In an article published by the National Institute for Communicable Diseases (NICD, 2014b), it is documented that, in South Africa, malaria transmission occurs mainly in three provinces namely Mpumalanga, neighbouring Limpopo and coastal Kwa-Zulu Natal. Currently, residual

indoor spraying is containing the disease and limiting its spread. It is further noted in a monthly publication by the NICD (2014a) that malaria cases spiked in Limpopo during the last two weeks of March 2014 mainly due to heavy rainfall and hot humid conditions. The link between climate (not just weather) and increased number of cases was not mentioned and dilutes the connectivity and future implications^{††}.

Morens and Fauci (2013) document that 60 to 80 per cent of new human infections are zoonotic while emerging and reemerging diseases are current human-adapted disease-causing agents which have genetically acquired a new means of transmission and / or pathogenesis. Most infectious diseases are preventable should there be no nonhuman host or reservoir (Morens and Fauci, 2013; Fauci and Morens, 2012; King, 2004, Link, 2007: 147). The challenge with these pathogenic organisms is their extraordinary adaptability. Africa is particularly burdened with disease carrying a double disease burden of communicable and non-communicable diseases placing them at greater risk (Githeko, 2009; Chukwuma, 2012). When considering the role of a National Health Insurance in South Africa, together with assessing resource allocation, Econex (2009) reported that South Africa has a unique quadruple burden of disease: communicable, non-communicable, HIV/AIDS (in its own category) and injuries, with a unique supply and demand on healthcare services and, therefore, unique costing and financial implications. The current situation leaves no room for an additional burden of disease - immunosuppression and poverty exacerbate spread and fatality. The new patterns in human behavior and movement – globalization, urbanization, the need for economic empowerment, the changes in land use and agriculture – are mixing with temperature and humidity changes creating opportunities for pathogens to spread and cause great harm. A ‘stable’ African climate is no longer a realistic concept (Hulme *et al*, 2004).

2.2.3 What the experts say

McMichael has written many articles on climate change and human health documenting in 2006 that we are heading toward a tipping of the ecological balance which could trigger an

^{††} During November 2013, I spent three days in Limpopo visiting the local clinics for the purpose of this research and experienced the climate to be extremely hot and humid – with resulting drenching rainfall. No awareness was made to the locals of the risk of malaria and the need to be protective.

epidemic (McMichael *et al*, 2006). In 2008, along with Woodruff, McMichael discussed climate change and infectious diseases and how mankind is disturbing the natural constraints on vector species by damaging ecosystems and altering species profiles. In that same year he published another article which called out for interdisciplinary research with regards to environmental change, climate and population health (McMichael and Woodruff, 2008; McMichael, 2008). In 2011, McMichael stressed environmental sensitivities and the impact on other sectors, including: food yields, water supplies, natural constraints on infectious diseases and natural protection against extreme weather conditions (McMichael, 2011). In 2013 and 2014, emphasis was applied to globalization, the Great Acceleration (our international connectivity), population growth, the excessive pressure exerted by mankind on the Earth's bio-geo-capacity, the Anthropocene geological epoch and the need for adaptation in which the health sector plays a significant role (McMichael: 2013, 2014).

In support of his writings, contributors such as Ostfeld, Patz, Campbell-Lendrum and Hulme have concurred that change in climate as indicated by the change in weather patterns is attributing to an increase in transmission threshold, geographic area shift, as well as expansion and resurgence of diseases. The South African Department of Environmental Affairs concurs and states that “increases in temperature and change in rainfall patterns in southern Africa are already favouring the range expansion of some vector-borne diseases such as Malaria and altering the range of tick-borne diseases” (DEA, 2010: 12).

Infectious disease-causing microorganisms and their arthropod vectors lack the ability to thermo-regulate and rely exclusively on extrinsic factors such as temperature, humidity and rainfall to provide an environment of optimal conditions for feeding, reproduction and development (Ostfeld, 2009; Patz *et al*, 2003; McMichael *et al*, 2006; Hulme *et al*, 2004; Githeko, 2009). As a result, distribution and intensity of vector- and water-borne infectious diseases are driven by climate. Using malaria in field studies, it was established by researchers that a small change in temperature can amplify the intensity of malaria infections as well as distribution because of the effect temperature has on the mosquito. To illustrate this, studies by Pascual *et al* (2006) have proven that the increase in malaria cases in the highlands of East Africa is due to an increase in temperature from sub-optimal to optimal ranges. An increase in temperature of 0.5°C in Western Kenya since the 1970s may explain the eight-fold increase in malaria cases (Githeko, 2009; Ostfeld, 2009; Haines *et al*, 2000). Interestingly, older civilizations were keenly aware of the link between climate and disease epidemics. Thus,

Roman aristocracy took refuge in high resorts to avoid malaria in summer (Patz *et al*, 2003). Even though infectious diseases may not necessarily expand in geographic area they will shift and change geographic location (WHO, 2005; Ostfeld, 2009; Moore *et al*, 2012). The point of concern with this phenomenon is that inhabitants of the new location may not have acquired immunity to deal with the insurgence of a new infectious disease or may be burdened with a high proportion of immunosuppressed inhabitants (Beltz, 2011: 9; McMichael *et al*, 2006).

Distribution and intensity of infectious diseases has been exacerbated by environmental changes, mainly loss of biodiversity (DEA, 2011), together with human social influences. Human movements associated with trade and travel increase disease distribution since travelers carry disease with them into new areas, food pathogens are transported with food produce and people migrate to cities in an effort to escape poverty in rural areas (McMichael, 2004). In addition, overcrowding, lack of potable water and adequate sanitation, poor public health services and remote areas favour the spread of disease (Beltz, 2011: 15-18; van Hasselt, 2011; Finkel, 2011: 8; Kishore, 2011: 41, 42; Sanders *et al*, 2008).

The implications of climate change on human health are not limited to infectious diseases since non-infectious effects lead to increased vulnerability and susceptibility to infections. The creation of urban heat islands caused by reduction in surrounding vegetation leads to heat exposure and can cause death. Drought and other climate extremes either directly destroy crops, or alter plant pathogen ecology which destroy crops leading to malnutrition and in extreme cases starvation and death (McMichael *et al*, 2008; Patz *et al*, 2005).

2.2.4 Predictions and early warnings

In our modern society, vector control, antimicrobial use and changes in infrastructure all mask the effect of climate on disease. However, this is not the case with animal disease where an increase in avian malaria both latitudinal and altitudinal has been observed since these are less influenced by the control measures (Altizer *et al* 2013). The challenge presents itself: to determine and measure the impact of climate-disease interactions on human societies, recognising the climate and environmental factors that increase the cause of infectious diseases (Altizer *et al*, 2013; Hulme *et al*, 2004; Davies *et al*, 2010). Predictive measures and early warning systems (EWS) need to be in place since the changes brought on by climate and the costs are incremental and cumulative resulting in more costly curative measures. Stakeholders

must be involved in the development of EWS since socioeconomic and political systems are embedded in them (Glantz, 2004). The South African government, in the NCCR White Paper, committed itself to continually develop and improve its early warning systems and ensure the warnings are carried to the vulnerable areas. It is noted that the government will use mass media to assist with communication (DEA, 2011).

Hay *et al* (2013) discusses global mapping of infectious diseases and makes mention of how modes of data gathering have improved and evolved - specifically Internet-based health reporting. Once infectious disease distribution maps have been set up, the community can use them to evaluate the factors that predispose a time and place to the origin and emergence of an outbreak. The review stresses that we have poor knowledge of the distribution of a vast majority of infectious diseases of clinical importance. The WHO, in a report entitled *Using climate to predict infectious disease epidemics*, published in 2005, affirmed that climate parameters can be used as predictive indicators in disease EWS. Three principle pathways in which climate impacts on infectious diseases are listed as: effect on human behaviour with regards to seasonal occupation, migration and winter-summer lifestyles; effect on disease pathogens with regards to incubation and development rates and; effect on climate-dependent disease vectors (WHO, 2005). Chaves and Pascual (2007) admit that EWS can lead to unreliable forecasts when dealing with the connection between climate and disease that is not fully understood. However, successful examples of prediction of 'out-of-fit' data based on the relationship between climate and disease is known. Such EWS have been successfully designed for malaria. Early warning systems are important in helping with adapting to climate change (Glantz, 2004; Patz *et al*, 2005). Altizer *et al* (2013) acknowledge that *host-pathogen interactions are embedded in diverse communities, with climate change likely leading to the loss of some host-pathogen interactions and the gain of novel species pairings*.

Moore *et al* (2012) predicted the effect of climate change on African trypanosomiasis, a disease listed as one of 12 zoonotic diseases most likely to increase in infection rate or change in geographical range due to climate change. Results obtained from the model indicate that the projected increases in mean annual temperature over the next 50 to 100 years are likely to cause a shift in parasite distribution to eastern and southern Africa. The conclusion reached by the researchers is supported by Hulme *et al*, the Wildlife Conservation Society and WHO (Hulme *et al* 2004; WHO 2005).

2.2.5 The public

Where does public awareness and health stand with regards to all the challenges facing us? Sauerborn (2013), in an article *Climate of uncertainty*, discusses man's role with regards to order and chaos. Man is discussed as perpetrator, being responsible for disrupting the Earth's natural delicate balance. Examples presented are acid rain in the '70s, ozone depletion in the '80s, and since the '90s – reducing the capacity of the Earth's natural sinks to restore balance. Man is discussed as victim, being affected by the above leading to greater maladies such as malnutrition and mental illness. Man is viewed as researcher, specifically to enable policy with a challenge in health research. Man is discussed as actor, in that willingness to implement change is lacking and global governance is regarded as “toothless”. A new global order of institutions is recommended and processes are to be implemented to protect health from chaos caused by climate change (Sauerborn 2013). An intensely important consideration is the integration of public health adaptation to climate change. Many consider climate change a conspiracy and will not be mobilised to make the necessary changes. However, the physical signs are present and the vulnerability of communities is visible. Adaptive capacity will be required. First and foremost, this should emanate from public health.

Public health is defined as “the science and art of preventing disease, prolonging life and promoting health through organised efforts of society” (Ebi *et al*, 2005:1). Prerequisites for public health action include an awareness of the problem, an understanding of the cause, sensing that the problem matters, having the capability to influence and the political will to deal with the problem (Ebi *et al*, 2005:6). Locally, Sanders *et al* (2008) ask the question: “**What is needed for health promotion in Africa: band aid, live aid or real change?**” Historically, colonialism in Africa influenced health promotion and governmental regimes failed in their attempts to promote health. The authors present requirements for health promotion as focusing on human rights, equity and other social determinants such as safe water, sanitation and education, to list a few.

2.2.6 Conclusion

It is regarded that no matter the challenge, we must maintain a ‘business as usual’ (BAU) stance. However, BAU costs of climate change are equivalent to a 5% reduction in per capita

income according to Grasso *et al* (2012) which may increase to 11%. In light of the damage man has caused and continues to cause a ‘business as usual’ approach is no longer an option (Sauerborn, 2013).

The general consensus is that infectious diseases pose a threat to human health and place stress on existing public health services - worldwide. Poverty, inequality and socio-economic factors determine the intensity of the threat. These factors impact on a population’s vulnerability and the greater the vulnerability, the weaker the ability to adapt leading to a disabled adaptive capacity and vulnerability to disease burden.

In addition, these factors cause humans to have a greater impact on natural systems – driving diseases out from their natural environment into one where they have no constraints and no boundaries. Human behaviour allows them the pathways needed to flourish.

Emerging infectious diseases have been addressed for over 20 years, recorded in a report from the Institute of Medicine in 1992 which predicted that unrecognised infectious diseases will continue to emerge and continue to remain a threat; 30 disease epidemics have emerged over this time with the majority being of animal origin and climate sensitive (Morens and Fauci, 2012; King, 2004; Hulme *et al*, 2004).

Policy formation, along with surveillance and primary health information, especially in poorer countries, are critical (Grasso *et al*, 2012). This has been recognised by the South African government and documented in the NCCR Green Paper of 2010 and the White Paper of 2011 which describe both mitigation and adaptation policies (DEA: 2010, 2011).

The impact is great on civil societies and specifically those faced with an increase in immunocompromised individuals (Beltz, 2011: 18). It is predicted that loss of healthy life years due to global climate change can be as much as 500 times greater in poorer African populations than in European populations. Research and analysis is required to improve surveillance and primary health information services (van Hasselt, 2011). In addition, Africa as a region will be impacted by water stress, reduced rain-fed agricultural yields and an increase in arid and semi-arid land (IPCC: 2014b).

Most studies have been conducted in high-income countries leaving future health trends and effects subject to uncertainties (McMichael *et al*, 2006). As a result, policy makers in poorer, vulnerable areas may not be convinced of the urgency and legitimacy of research and change.

The Council for Scientific and Industrial Research (CSIR) presents a handbook for Southern Africa entitled **Climate Risk and Vulnerability** which describes the impact of climate change on Southern Africa and the populations contained therein. Of specific reference is the impact on human health and ecosystem responses to climate change (Vincent *et al*, 2011: 56, 60). It may be more attractive to a leader to take on debt for development as opposed to debt for greenhouse gas emission abatement especially since research has indicated that development is a cheaper way to reduce the impact of climate-induced diseases. It is therefore more attractive to high income countries to compensate poorer countries for the climate change damage caused (Tol, 2008).

In this time of uncertainty, we need not grope in the dark: global networks and social movements are creating awareness amongst policy makers (Sanders *et al* 2008; DEA: 2010, 2011). But we do require more local research studies, providing information that can be made available to the public and specifically healthcare workers.

The research conducted for the purpose of this dissertation is aimed at contributing to the pool of articles on the subject of climate change and infectious disease patterns to gain insight on public healthcare awareness and the impact of climate change on health provision in South Africa. Do we need a scare in order to sit up and take note? How vulnerable are we? How strong is our adaptive capacity?

2.3 Climate Change and Human Health

2.3.1 Introduction

Global climate change is understood to mean *change in climate over time*, due to either natural variability or anthropogenic activities and incorporates temperature increases, sea level rises, snow and ice depletion and changes in precipitation. These are factors described within the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC, 2014b). The IPCC has been monitoring climate change events for almost three decades, having been established in 1988 by two United Nations Organizations, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). The panel was to assess ‘the scientific, technical and socioeconomic information relevant for the understanding of the risk of human-induced climate change. Their first assessment report was

published in 1990 playing an important role in establishing the negotiating committee for the UNFCCC. The findings concluded that anthropogenic climate change will persist for centuries, indicating that action is required to address the gaps in information and understanding with research advances being relayed in order to assist policy makers (IPCC, 2014a). The fourth assessment report published in 2007 makes the clear statement that *warming of the climate system is unequivocal* and indicated an expected average global increase in temperature of 0.2°C per decade as a result of the current increase in greenhouse gas emissions with the forecasted 1.4 – 5.8°C by the year 2100. Should these gas emission levels be held constant as at the year 2000, it is predicted that a temperature increase of 0.1°C per decade will be experienced. Between the years 1995 and 2005, projections assessed a global temperature increase of between 0.15°C and 0.3°C supporting the 0.2°C prediction (IPCC, 2007a).

So, what difference can a slight increase in temperature really make? How will human health be affected? Will a warmer climate not benefit some? Africa has, for the most part a warm climate (tropical and temperate) and the inhabitants are hardy and adaptable, what are the concerns should it get warmer?

2.3.2 The relationship

“Loss of healthy life years as a result of global environmental change (including climate change) is predicted to be 500 times greater in poor African populations than in European populations.” (van Hasselt, 2011).

All biological systems are sensitive to climate and function best within certain adapted parameters. Should those parameters be altered, the system will have to re-adapt. The adaptation could be a change in normal functioning in the existing environment (as bacteria mutate or parasites undergo antigenic variation) or a change in environment from an existing locale to a new geographic area that offers the required parameters. Biological systems will adapt or die should the conditions not support their functioning.

The effect of change in climatic parameters, and more specifically temperature increase, on human health (a biological system) has been investigated exhaustively and is expressed to take the form of heat exposure, malnutrition (from food insecurity), diarrhoea, cardio-vascular

diseases, allergies (from an increase in air pollutants), food-borne diseases as well as water- and vector-borne infectious diseases (Grasso *et al*, 2012; IPCC, 2007a; Epstein, 2002; McMichael, 2001a). In line with this, the link between climate change and infectious diseases is noted by the movement or migration pattern exhibited by vectors carrying infectious disease-causing agents. As plants and animals are observed to be migrating to higher altitudes – fleeing from the change - so are these vectors, such as *Anopheles* carrying malaria and *Aedes* carrying dengue (McMichael, 2001a; Haines *et al*, 2000; Hulme *et al*, 2004). These vectors, mosquitoes for this example, adapt to changes in their environment by moving to another more suitable one (Patz *et al*, 2003; Vincent *et al*, 2011: 56). It must be noted that other infectious diseases, schistosomiasis, for example, may show a reduction in transmission with change in climate due to the impact of increased precipitation and flooding on their breeding sites (McMichael, 2001b). Regardless of this the South African Department of Environmental Affairs still believe schistosomiasis may spread due to climate change (DEA, 2011). Climate change can tip the ecological scales through altering temperature, rainfall and habitat, thereby triggering epidemics significantly affecting vulnerable, marginalised communities where public health service infrastructure is not accessible or may be inadequate (McMichael *et al*, 2006). Predictions of the impact of climate change on human health in the future will greatly assist policy makers now to nurture adaptive and thereby preventative capacities specifically among vulnerable populations.

Africa as a whole contributes the least to greenhouse gas emissions and has one of the lowest energy consumption rates per capita (IPCC, 2007a). Yet, it is recorded that Africa is particularly vulnerable to the effects of climate change and infectious diseases as it carries the greatest disease burden - 25% of the world's total (Dube and Chimbari, 2009; Rao *et al*, 2010; Robinson and Clark, 2008). Adaptive capacity varies among the African states but remains limited overall mainly due to poverty, droughts and water stress, equity imbalance, conflict and dependence on environment sensitive sectors such as rain-reliant agriculture (Smit *et al*, 2001). The Regional Climate Change Programme (RCCP) expressed the need for trans- boundary adaptation to climate change in Southern Africa stressing the need to *collate, generate and disseminate information* – specifically directed at policy makers and planners (van Hasselt, 2011).

Public health systems and health promotion remain under severe strain due to the current burden of disease as signified by the disability adjusted life years (DALY) and the lack of

qualified healthcare and primary care workers (WHO, 2003; Rao *et al*, 2010; Dube and Chimbari, 2009; Sanders *et al*, 2008; Robinson and Clark, 2008; Econex, 2009). According to Sanders *et al* (2008) changes made to resource allocation after the dissolution of the Reconstruction and Development Programme established in 1994 has resulted in health promotion receiving neither power nor resources. As a result, a curative approach to healthcare remains rather than an educated preventative approach.

2.3.3 The economic effects

“Are poor people more likely to get sick, or are sick people more likely to be poor?”
(Chase, 2012)

There is a definite association between disease and economics – burden of disease is greatest in poorer areas as these are less able than more affluent economies to invest in healthcare, immunisation, quality of food, control of vectors and treatments for the sick. There is a definite link between disease and climate change – changes in temperature, humidity and precipitation affect reproduction, development and feeding of vectors and parasites as well as human and animal behaviour. What, therefore, is the definitive link between economics and climate change?

A study done by Oxford Economics (2010) set out to determine the quantitative economic impact of cholera in Mozambique and Bangladesh and used macroeconomic simulation models based on South Africa and India. The estimated impacts, as indicated by the study, were a decrease in GDP of 2-2.5% for the same year of the epidemic and 0.5-1% for the following year. The study also indicated a loss of exports, a reduction in consumer spending with expected job losses and a small increase in consumer prices. The study based its findings on demand and supply. Demand in the form of consumer spending: income, employment and real interest rates. Supply in the form of population growth, the speed with which capital is available and increases, and the total factor productivity growth.

Tol (2010) approaches the economic impact of climate change in terms of cost-benefit of reducing greenhouse gas emissions. Statistical and enumerative approaches were used to estimate the outcome. As energy and energy services increase the cost of living and running a

business goes up. As a result, households save less, businesses invest less impacting negatively on the economy. This presents a problem for policy makers; especially when acknowledging that CO₂ is not the only greenhouse gas to reduce – methane and nitrous oxide are equally noxious and prevalent in the atmosphere. These gases are, however, intrinsically part of our food production and energy system. Once again, it is noted that those that contribute least to these emissions suffer the most. The economic impacts of climate change are varied and Tol lists significant missing impacts:

Negative - Increased water temperature increases cost of cooling power plants; extratropical storms damage buildings and infrastructure; ocean acidification harms fisheries.

Positive - High speed winds reduce costs of wind and water energy; reduction in sea level reduces hindrance to entry of arctic harbours; reduction in clothing expenditure.

Mixed – Tourism changing site – redistribution of tourist revenue.

Unknown – Biodiversity loss; extreme climate; violent conflict and the long term.

There will be an impact on nature. Regrettably, countries overall spend less than 1% of their income on nature conservation. Questions arise such as *Willingness to Pay* (WTP) and *Willingness to Accept Compensation* (WTAC) for diminished services. WTP has no emissions as default and WTAC has no climate change as default. WTP violates the ‘do no harm’ principle of law. A century of climate change is equivalent to a year of economic growth and with that the challenge: emission reduction must not carry a high cost. The European Union has a reduction target of 20 – 30% from 1990 rate by 2020 – a very high target with the argument leaning toward 10 – 15% reduction for the 21st century (Tol: 2008, 2009, 2010).

Why should we care? The answer is mainly because more affluent nations are exporting the ecological effects of climate change into poorer more vulnerable nations. Thomas *et al* (2008) studied vegetation changes since these significantly affect the habitats of terrestrial species – of which man is one. A dynamic global vegetation model was used that was based on two time periods, 1945 (1931 – 1960) and 2045 (2041 – 2050), and focused on plant type distribution. A major vegetation shift was noted and predicted for 2045, specifically in dry arid regions. Vegetation and woody plants increased in area due to higher CO₂ levels which reduces water stress allowing these plants to survive periods of drought. It is, once again, mentioned that countries least responsible for climate change with the least economic means to develop and

adapt experience the greatest changes – specifically with regards to biodiversity. The exports filtering in to these vulnerable biodiversity-rich regions should cause biome changes and climate deviation (Thomas *et al*, 2008).

This leads to the research carried out by Bonds *et al* (2012) who used a simultaneous equations model to estimate the relative effects of vector-borne and parasitic diseases (VBPD) and income on each other. They note that one-sixth of the world is approximately as poor today as their ancestors were hundreds of years ago and 93% of the global burden of VBPD is carried in the tropics which hosts 41 of the 48 least developed countries with only 2 of 34 having advanced economies. These VBPD are a leading cause of morbidity and mortality in poor populations and systematically influence economic growth. There is *implicit agreement that the geography of human health has had significant impacts on economic development*. An argument often relates this to historic colonialism and not intrinsically economic productivity. Life expectancy or DALY has significant economic impacts and the economic conditions of the poor are often due to biological processes manifest in health status. Climate – mainly tropical – is specifically associated with higher incidence of vector-borne and parasitic diseases (VBPD), most specifically malaria, leishmaniasis, schistosomiasis, ascariasis and hookworm. Biodiversity is significantly affected by climate change – and economic stress – thereby reducing the natural constraints of VBPD. Countries situated at higher latitudes tend to be wealthier than countries situated at the tropics. This may be due, once again, to historic colonialism or, as most likely, the burden of disease.

An article published in PLoS Biology in December 2012 by Jonathan Chase entitled ***Which Came First: Burden of Infectious Disease or Poverty?*** analyses the abovementioned research article by Bonds *et al* (2012) expressing the important point that we, as inhabitants of one world, are embedded within a complex ecological web embracing human and animal interactions. The statement is made that the relationship between infectious diseases and prosperity is so intertwined it is difficult to determine *whether pathogens drive economies or economies tame pathogens*.

In discussing the research done by the interdisciplinary team of ecologists and economists it is determined that wealthier countries tend to be at higher latitudes and tropical countries tend to be poorer mainly due to the burden of disease. The study showed that there is a negative link

between biodiversity and the infectious disease burden with direct consequences for per capita income.

2.3.4 Conclusion

Vector-borne and parasitic diseases reduce quality of life, life expectancy and affect the economy of a region. Vectors and parasites are dependent on climate for reproduction, development and feeding. These vital activities are mainly accelerated by increased temperature and humidity. Areas vulnerable to variations in climate, such as those within the tropical zone, will be exposed to an increase in infectious diseases and a decrease in economic growth.

Many diseases are associated with economic development which drives people into urban areas resulting in overcrowding and lack of civil services such as potable water and sanitation or moves them to invade virgin forest areas bringing disease out with them.

It is economic development that is changing our planet's climate so significantly and altering the natural behaviour of all its inhabitants – micro to macro.

In our current time, wealth is directly linked to economic development and not to natural resources. Natural resources are thus being sacrificed at the altar of monetary possession and the possessors of this wealth are not inclined to change in order to reduce the impact economic development is having globally.

As indicated by the literature, the economic effects of climate change range from welfare and health to biological and ecological system failures. The industries and sectors that provide food and energy are the same industries and sectors spewing out noxious gases or altering animal and land use leading to the climate changes that have been observed for almost a century. The next century will reveal even more if changes are not made sooner. So what is the trade-off?

2.4 Infectious Diseases

2.4.1 Introduction

Research has indicated that infectious diseases (especially those transmitted by arthropod vectors) are predicted to shift in geographic location as climate change causes an increase in

temperature – specifically minimum temperatures (Ostfeld, 2009; Tabachnick, 2009; Pascual *et al*, 2006). Climate conditions set the limits for survival and replication of pathogens and vectors as well as human behaviour. Natural constraints on vector-pathogen species are being thinned out due to the effects of human behaviour on natural ecosystems, by altering species profiles and land use, bringing humans and vector-pathogens closer increasing opportunities of contact and transmission (McMichael and Woodruff, 2008).

Regardless of personal views on creation and evolution, one cannot look beyond the existence of microorganisms and the role they play. Microorganisms co-exist with man on so many different levels – gut microbial flora assisting with digestion, producing Vitamin K and keeping potentially harmful pathogens at bay, microscopic mites cleaning the surface of the skin and scalp – for the most part a symbiotic relationship. Some, on the other hand, may not live in such harmony with man and part of their life cycle is within other mammals which may serve as reservoirs for potential human pathogens and emerge as zoonoses. Others spend part of their life cycle in arthropods using them as a type of incubator and vehicle to infect mammals and emerge as vector-borne zoonoses or anthroponoses. Still others use crustaceans and small sea or fresh water dwelling creatures in which to develop and transmit disease to mammals such as bilharzia caused by a parasite developing inside, and being transported by, a fresh water snail.

Bacteria have a silent sophistication in cunningly changing to outsmart efforts to kill them. For example bacteria may take up DNA from a plasmid that codes for a protein enzyme specifically against the active portion of an antibiotic (beta-lactamase and carbapenamase) and, thereby, remain a constant threat. Pathogenic viruses are transported within a reservoir, enter a host, replicate rapidly and spread to other cells easily passing from one host to another. They have the ability to mutate, or change, the sequence of their genomes that may change their envelope proteins to evade detection by the host immune system. This alters their antigenic properties, making vaccine development impossible. Parasites, too, have this type of armoury allowing regular change in their protein coat to avoid attack by their host's immune system. This contributes often to death – trypanosomiasis being an example of this. Fauci and Morens (2012) refer to this as their “extraordinary adaptability”.

Microorganisms serve a purpose although in most instances this has not been fully identified. Microorganisms are practically harnessed for good – in the making of food products and

beverages such as yoghurt and beer – and are eradicated when their impact is bad. Often these latter measures involve targeting their vectors or reservoirs in order to disrupt their life cycle, reduce their numbers or destroy them.

The argument remains though: if microorganisms exist in natural environments they must be serving a purpose. When removed from that natural environment they can only cause great harm – since their natural constraints are no longer there to control their transmission and activities. Most organisms in nature live in harmony and balance but man has the facile ability to upset that harmony and balance. Movement of microorganisms is considered a geological force into an Anthropocene geological epoch (McMichael: 2013, 2014). In this instance, we are considering the movement of microorganisms from their natural ecosystems, allowing their engaging in behavioural changes and providing culture media within which they can flourish. The behaviour of humans with regards to the environment and each other, specifically in terms of economic development and globalisation, is allowing infectious diseases to flourish (Lee *et al*, 2011). More and more *indigenous* microorganisms (viruses, bacteria, parasites) are being plucked from their place of safety and brought into an *alien* environment^{§§}.

Arthropods and mammals are dependent on temperature, humidity and rainfall for survival. Their reproduction, development and feeding are all determined by natural hydrological and meteorological cycles and events, changing these cycles and events will cause change in those dependent on them (Epstein, 2002). As we continue ploughing forward in our vehicle of climate change more and more infectious disease epidemics are bound to surface, specifically of zoonotic origin. We cannot expect our actions to have no consequences.

2.4.2 Current distribution of selected infectious diseases

This study focuses on a few infectious diseases that are controlled and affected by climate with regards to development, breeding and feeding involving as they do either vector-borne or water-borne transmission. These are specifically malaria, trypanosomiasis (both vector-borne), schistosomiasis and cholera (both water-borne). The first three diseases are caused by parasites, whilst cholera is a bacterial infection. These diseases most commonly afflict vulnerable

^{§§} At the time of writing, we were experiencing an Ebola outbreak in parts of Africa claiming over 3,000 lives thus far. The virus is known to reside in at least three species of fruit bat native only to Africa (Willey, 2008: 1001-1006). Contact with these animals – mainly due to habitat invasion – has caused the virus to infect humans and spread.

populations in sub-Saharan Africa, mainly due to their close contact with animal reservoirs and the environment as well as the lack of potable water and sanitation (Fauci and Morens, 2012). The populations most at risk are those reliant on their natural environment and those situated far from public healthcare facilities.

Table 2-1 summarises the distribution, habitat and transmission of known diseases sensitive to climate and may exhibit a change in geographic location due to changes in climate.

Table 2-1: Current distribution, habitat and transmission of selected diseases

Disease	Distribution	Habitat	Transmission
Malaria	Worldwide with endemic areas in Africa – specifically those of low socio-economic means	Require a body of water in which to deposit eggs with tropical to sub-tropical temperatures	Patient is bitten by female anopheline mosquito infected with the malaria parasite
Trypanosomiasis	East and West Africa	Ranges from tropical forest to drier savannahs and riverine areas	Patient is bitten by a tsetse fly carrying the trypanosome parasite
Schistosomiasis	Throughout Africa especially in poor communities with no access to clean, safe drinking water and poor sanitation	Favours tropical and sub-tropical areas and freshwater sources	Patient is in direct contact with water contaminated with the schistosome parasite from faeces of an infected person
Cholera	Developing countries and areas of poor sanitation and no access to clean water – known in Africa, Asia and Haiti	Brackish water and estuaries; associated with algae and marine life (shellfish)	Patient ingests or has direct contact with water or food contaminated with faeces from infected person

Some sources consider schistosomiasis and trypanosomiasis to be relatively insensitive to climate change due to their low reproductive rates (Hulme *et al*, 2004), while others, such as the Wildlife Conservation Society and the WHO consider trypanosomiasis as one of twelve wildlife or zoonotic diseases most likely to increase in infection rate or change in geographic range due to climate change (Moore *et al*, 2012; WHO, 2005). Regardless of the opinion, populations at risk must be identified, and healthcare workers sensitised and made aware of the need instil protective and precautionary measures in the event that novel disease outbreaks occur within the communities they serve.

2.4.3 Potential to change geographic location

Many infectious diseases are known to be region-specific. For example, haemorrhagic fevers are known to occur in central and West Africa and may not naturally occur in built up bustling cities while trypanosomiasis is endemic to 36 sub-Saharan African countries with a risk population estimated at between 60 - 70 million. Of these, 80% of cases are reported in the DRC (Moore *et al*, 2012). However, African trypanosomiasis is considered one of twelve wildlife or zoonotic diseases most likely to increase in infection rate or change in geographical range due to climate change. “Climate change has been implicated in the emergence and re-emergence or range of expansion of many wildlife and human diseases in recent years, such as cholera, West Nile virus [and] malaria”. Change in climate causes shifts in tsetse fly ranges and distribution by altering environmental suitability (Moore *et al*, 2012). This research indicated that projected increases in mean annual temperature over the next 50 - 100 years are likely to cause a shift in parasitic distribution to eastern and southern Africa – a shift in geographic area, into areas of naïve wildlife and domestic animal populations increasing transmission rates spilling over to humans.

Mosquitos, and other arthropods, are temperature sensitive (Githeko, 2009) and, thus, temperature constrains their range. Yet, these are appearing in mountainous regions where plants and freezing levels have shifted upward (Epstein, 2002). Species may be in the process of adapting genetically (genetic shift) in response to changes in climate and the effects on seasons – an evolutionary response to global warming. The existence of future biotic communities may very well depend on the adaptive ability of their current constituent species. An example of this was described by Bradshaw and Holzapfel (2001) on mosquitoes,

specifically the purple pitcher plant mosquito, *Wyeomyia smithii*, identified as genetically changing (evolving) to keep up with change in climate and the later arrival of winter.

Vegetation change is the most significant climatic effect on infectious disease distribution since this affects the habitats of terrestrial species (including disease vectors and their hosts). Carbon dioxide levels affect the growth of various plant types in a moderate climate change scenario making these plants experience less water stress, being able to survive periods of drought (Thomas *et al*, 2008). The study was conducted on the predicted change in vegetation biome but was not restricted to regions where vegetation is projected to shift from one biome to another. Since vegetation is a source of food and shelter for animals and insects, a change in distribution patterns of vegetation will naturally mean a change in distribution of these animals and insects.

Adding to the concern that infectious diseases can surface in new areas, is that these discoveries may not be reported by an affected region or country due to the economic consequence reporting an outbreak may have. Poor compliance to report outbreaks of cholera, plague and yellow fever require incentives – which often are not available or attractive enough. An emphasis must therefore be placed on adaptation strategies in order for vulnerable human societies to protect and promote human health (Lee *et al*, 2011). Correspondingly, awareness on the nature of infectious diseases, their modes of transmission, symptoms and treatment must be made available to those most vulnerable and in areas not easily served by public health facilities.

Influenza provides an example of the rapid spread of an infectious disease, specifically with regards to an antigenic shift that is magnified by globalisation (Lee *et al*, 2011).

2.4.4 Conclusion

Our climate is changing and associated with that are changes in plant (vegetation) distribution and animal (including human) behaviour. Vegetation supports terrestrial life and any change will affect the animal populations it supports. Research has determined that vegetation is migrating to higher altitudes and biomes are shifting (Thomas *et al*, 2008) implying that dependent animal populations will migrate as they search for food. These animal populations often serve as pathogen reservoirs and may bring pathogens closer to vulnerable human communities.

Arthropod vectors are particularly sensitive to climate (Githeko, 2009; Bradshaw and Holzapfel, 2001); research has been done specifically on mosquitoes indicating their reliance on climate for reproduction and development as well as how they can genetically adapt to changes.

The potential for a vector-borne infectious disease to change geographic location requires more research and study but it has been noted that these diseases can be brought out of their natural environments and enter naïve communities. In 2012, the Centres for Disease Control in Atlanta, USA, received a letter from a doctor and his associates serving at the Laveran Military Teaching Hospital in France informing of a French expatriate who had been positively diagnosed with Human African trypanosomiasis (HAT). He had been working in Gabon for 13 years for a French company and was reportedly bitten by a tsetse fly 2 months prior to his being admitted to the hospital. Of significant importance is that his occupation did not place him in a position of exposure to the tsetse fly - the bite occurred in his garden at his home. The letter mentions two studies that have provided evidence of urban transmission – one in Kinshasa, Democratic Republic of the Congo (DRC) and another in Bonon (Cote d'Ivoire). It is noted that the tsetse fly species *Glossina palpalis* adapts to areas of high human density and have been found in western Africa urban centres (Simon *et al*, 2012).

It is to be noted that HAT is a known travel-associated disease and the letter indicates how penetrable our environments are to vectors.

Preparation and awareness are no longer considerations, they are requirements.

2.5 Public Healthcare and Early Warning Systems

2.5.1 Introduction

To provide and ensure preparedness and awareness of changing disease patterns – what are the requirements? How can these be implemented in our societies today, especially when societies are not exposed to the same amenities and social infrastructures?

The World Health Organisation emphasises early detection for effective interventions to control disease and reduce mortality rates. Infectious diseases are linked to climate with regards to geographic and seasonal distribution. Climate parameters can be used as predictive

indicators in disease early warning systems (EWS). In the face of evidence that climate change is due to anthropogenic activities climate specific EWS are of particular interest (WHO, 2012).

Predictive models and early warning systems (EWS) are essential components in creating awareness and ensuring preparedness. The key is that these tools are in the hands of guardians who will use them not for personal or political gain, but for serving the community – especially communities containing vulnerable individuals.

Predictive frameworks, global mapping of infectious diseases, and a specific example of prediction and future risks are discussed below.

Vector-borne disease cycles are complex and can be described as forming part of an episystem. An episystem consists of vectors, hosts, pathogens, biological controlling mechanisms and all environmental factors that affect disease epidemiology, as depicted in Figure 2-1 (Tabachnick, 2009).

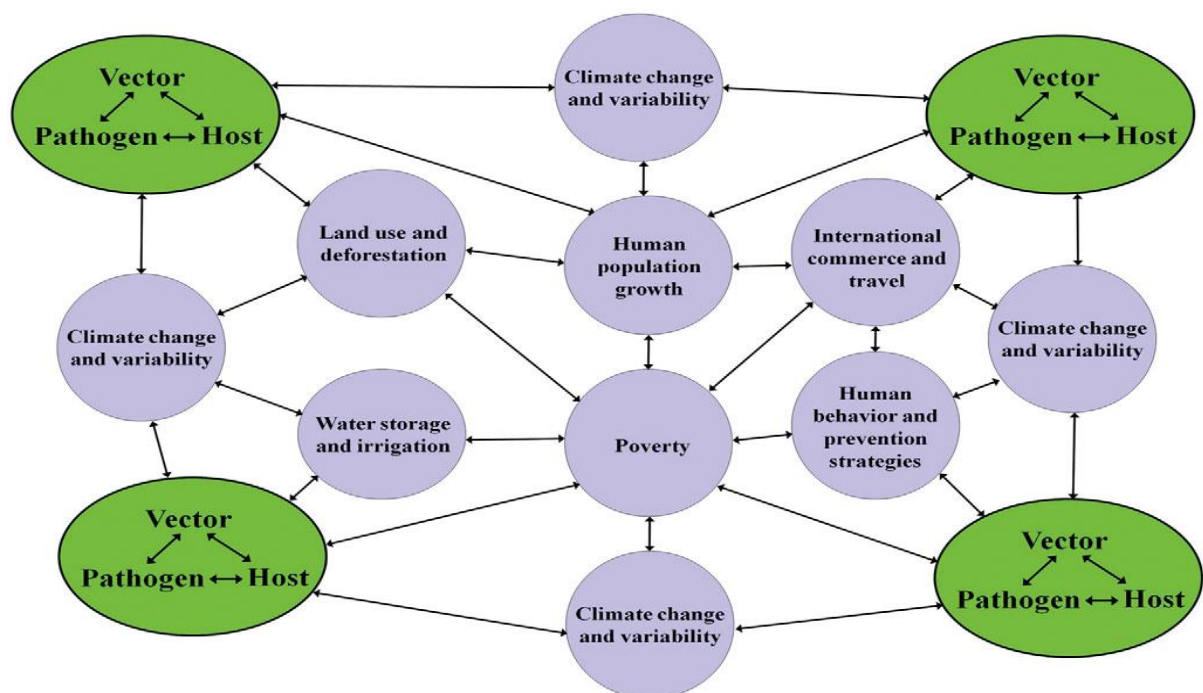


Figure 2-1: The vector-borne disease episystem (Tabachnick, 2009)

2.5.2 What are predictive models and early warning systems?

Predictive models and early warning systems are only as good as the basis on which they are designed and built. Predictive frameworks for infectious diseases must integrate knowledge

from ecophysiology and community ecology with modelling approaches. As mentioned in the previous chapter, the life cycles and transmission of many infectious agents are affected by climate. According to Altizer *et al* (2012), in modern society, vector control, antimicrobial use and changes to infrastructure can mask the effect of climate on many human diseases. In animals, however, the effect is more apparent. For example, the climate effect on human malaria is debatable, but the effects on avian malaria consistently show an increase in intensity as well as latitudinal and altitudinal range. An approach to predicting how host-pathogen interactions respond to increased temperatures would involve fusing epidemiological models with information derived from the metabolic theory of ecology (MTE)^{***}.

This means that ecophysiological studies must consider multiple host species and parasite developmental stages each with different sensitivities to warming bearing in mind that climate change is likely to lead to the loss of some host-pathogen interactions with the gain of *novel species pairings*. Thus, predictive frameworks must consider that some pathogens may die out as a result of climate change leading to reduction in disease **or** the releasing of other pathogens from competition. Biodiversity loss may also lead to an increase in transmission rate. It is, therefore, important that the broader context of global climate change such as land use change and habitat loss be included as part of the framework. An increasing number of articles have been written about climate-disease interactions with the best examples involving the climate responses of infectious disease agents that have ectothermic hosts and environmental transmission stages that can persist outside the host. Identifying the contribution other environmental variables play in disease transmission remains a challenge.

A better understanding of mechanistic factors will be required, such as the effect of precipitation, relative humidity and extreme events. In extending this argument, determining the impact of climate change on disease interactions in human societies remains the greater challenge – significantly so in light of the lack of compliance by some governments to report infectious disease incidences to authority groups (Altizer *et al*, 2012; Woolhouse, 2011).

^{***} According to Brown *et al* (2004), the theory offers a predictive framework for assessing and responding to human-induced changes in the abundance, distribution, and diversity of organisms, and the fluxes of energy and materials in ecological systems.

Global mapping of infectious diseases, as evaluated by Hay *et al* (2013), requires knowledge of the geographical distribution of all infectious diseases. The minimum information required on the epidemiology of an infectious disease in order to make an informed decision regarding the mapping of the selected disease is established and presented below in table 5-1. As modes of gathering data evolve and improve, along with Internet-based health reporting and techniques that manipulate the data, the geographical distribution of disease can provide a *normal* against which outbreaks can be assessed. Collectively, the infectious disease distribution maps can be used by the public health community to evaluate the factors that predispose a time and place to the origin and emergence of outbreaks. Disease-related metrics are used when collating the maps, such as occurrence, incidence, and prevalence together with other covariates making global comparisons difficult and synthesis elusive.

Prevalence surveys record data that are useful for mapping in that they locate a disease in time and space as well as measure the infected fraction of the sampled local population quantifying the abundance of a disease – referred to as endemicity. However, Hay *et al* (2013) conclude that we have poor knowledge of the global distribution of the majority of infectious diseases that have clinical significance.

Model-based geostatistics (MBG) have recently been applied to infectious disease mapping since these deal with spatial autocorrelation of disease data, can be configured to allow for factors that affects disease endemicity and by using Bayesian inference outputs can show full uncertainty of prediction. Of particular interest in our society filled with social media forums, crowd-sourcing can be used to obtain data, using large numbers of non-experts for data filtering. Online games can be used as a guise for obtaining data and online tasks can have a pay-per-example setting.

Moore *et al* (2012) set out to predict the effect of climate change on African trypanosomiasis as they realized that climate change has been implicated in the emergence, re-emergence and range expansion of many wildlife and human diseases. Since multiple parameters affect disease epidemiology, predictive models must incorporate these parameters. Thus, their research focused on incorporating the effect of mean annual temperature on epidemiological parameters of African trypanosomiasis in order to understand the impact of climate on the geographical range of the parasite in Eastern and Southern Africa. Additional warming will affect the epidemiology of vector-borne diseases by altering development rates of vector and

pathogen, shifting geographical distribution and altering transmission dynamics. Trypanosomiasis persists in reservoir hosts between outbreaks but the change in climate can see a shift in tsetse fly range and epidemic outbreaks.

Table 2-2: Minimum requirements for mapping diseases of clinical importance (Hay *et al*, 2013)

<u>Minimum requirements for mapping diseases of clinical importance</u>
1. Knowing the life cycle of the pathogen, its vectors, hosts, reservoirs and modes of transmission
2. Knowing the spatial and temporal patterns of the disease
3. Understanding the dynamic processes of transmission – including epidemiology and knowledge of covariates such as temperature, rainfall, land use patterns, biodiversity and vector involvement
4. Obtaining the quantitative and qualitative data available for mapping - health related data may be protected by governments and other institutions or may be widely scattered
5. Previous efforts made to map the disease - the longer the history of the disease, the greater the likelihood of reliable mapping outcomes

Results from the model indicate that the projected increases in mean annual temperature over the next 50 – 100 years are likely to cause a shift in parasite distribution to Eastern and Southern Africa, resulting in an increase in the number of people at risk of infection. The model does not predict a major expansion, more so a shift in geographic area of outbreaks. The shift into areas of immunological naïve wildlife and domestic animal populations will increase transmission rates and the chance of spill-over to humans.

Mean temperatures are an important determinant of distribution, but other environmental factors also play a role: relative humidity, minimum and maximum temperatures, vegetation and host availability. Important to note is that the disease cannot be sustained without the reservoir host. However, land use changes and climate (affecting reservoir host distribution) alter distribution of these host animals potentially increasing contact between wildlife and domestic animal populations and humans.

Woolhouse (2011) adds to the pool of knowledge on predictions about future infectious disease risks by looking at three risk areas:

- i. An exotic or novel infection appears in a given host population;
- ii. How fast will that infectious disease spread and how many of the population will be infected;
- iii. What would happen if there is an intervention in the form of treatment?

Taken together, quantitative models are required to incorporate inter-disciplinary research, a challenge exacerbated by using the past as a guide to the future.

Table 2-3: Various approaches to predictive modelling (Woolhouse, 2011)

Various approaches to predictive modelling
Expert opinion
Statistical methods
Risk modelling
Dynamic modelling

Table 2-4: Data inputs for predictive modelling (Woolhouse, 2011)

Data inputs for predictive modelling include:
The disease
The host
The environment

With regards to the disease, data concerning the latent, incubation and infectious periods must be collected. Surveillance data describing the distribution and spread of infection through space and time must be collated. Host demographics are required including age, gender, density and spatial distribution. In addition, host movement must be known and monitored together with phenotypic and genotypic characteristics. Added to this is the issue of reservoirs and vectors. The environment must be brought into the model including hygiene, climate and land use.

Climate change modelling has been successful in informing policy and is considered ‘sufficiently accurate’ to be useful. For infectious disease modelling, predictions are not that successful. Often this is due to a lack of data and often due to an unwillingness of governments to share data. Many countries do not want to share information regarding outbreaks for concern that international trading will be affected. Incentives may be provided for reporting diseases – specifically human – to compensate for any potential loss due to reporting.

A challenge exists in future to integrate the disparate kinds of activity in order to provide more reliable and useful predictions (Woolhouse, 2011).

Chaves and Pascual (2007) recognise that EWS can provide unreliable forecasts. However, these can successfully provide ‘out-of-fit’ data. Such EWS have been successfully designed for malaria and can also be used for neglected tropical diseases which place a burden on

developing countries and are sensitive to climate change. Forecasts are useful in planning services for affected populations. The authors note that sustained surveillance and monitoring efforts are key and EWS do not replace their function.

Table 2-5: Principle pathways in which climate change impacts on infectious diseases (Chaves and Pascual, 2007)

Principle pathways in which climate change impacts on infectious diseases
1. Effect on human behaviour with regards to seasonal occupation, migration and winter-summer lifestyles
2. Effect on disease pathogens in that pathogen development requires specific temperature threshold and higher ambient temperature shortens development time and increases reproduction rates.
3. Effect on disease vectors since insects are highly dependent on temperature, rainfall and humidity. An increase in temperature increases metabolic rate, egg production and frequency of blood meals. Temperatures in excess of the tolerance range may increase vector mortality. In addition, relatively wet conditions create favourable insect habitats

Features of early warning systems

Both climatic and non-climatic factors should contribute to and be incorporated in a predictive EWS. Fortunately, lessons from historical early warning systems suggested that it is possible to develop an effective system without complete knowledge of the effects of climate on all components of the disease transmission cycle.

Development of EWS is the outcome of a decision-making process. The disease/s of interest is identified and the burden of disease as well as available funding is assessed. An extensive literature review is done in order to set out the framework for constructing the climate-based infectious disease EWS. Four preliminary phases are required together with the response and assessment phases: i) evaluating epidemic potential; ii) identifying geographical location of

epidemic prone populations; iii) identifying climatic and non-climatic disease risk factors; iv) quantifying the link between climate variability and epidemics. The two principle aims of an early warning system is to identify whether an epidemic will occur within a specified population and to predict the number of cases that will occur within a defined period of time (WHO, 2005).

According to Glantz (2004), EWS must include the five W's: What, Why, Who, Where and when as inputs and indicators. The role of media and the link to sustainable development when designing an EWS should be considered. In addition, an EWS requires constant evaluation and must be maintained; it cannot simply be designed and left since the hazards being monitored are themselves dynamic and constantly changing (Glantz, 2004).

International regulatory bodies exist that are involved with monitoring and surveillance such as the International Health Regulations (IHR) managed by the World Health Assembly (WHA) via the WHO Director-General, specifically with regards to the impact of globalisation on human health. Under the IHR, countries are obligated to report adverse health events that have the potential to spread across borders (Lee *et al*, 2011).

2.5.3 How do predictive models make a difference?

Populations are most vulnerable when unable to adapt to changes in their physical environment, especially due to unawareness and lack of knowledge. Most animal populations have an acute adaptive capacity and tend to survive changes to their environment with the obvious exception being when such changes go beyond their ability to adapt. Adaptive capacity amongst human populations is greatly determined by poverty, awareness and access to facilities that can assist them in adapting. Surveillance data can be important in conveying information regarding risk to the public, notably via healthcare facilities. Knowledge of disease patterns allow comparisons to be made among different social and ethnic groups, in so doing improve recognition of lifestyle or behaviour patterns that threaten well-being and encourage multinational comparisons to highlight weaknesses or areas requiring attention (Wilson and Anker, 2005). The obvious implication from this is the need to canvas the opinion of healthcare workers within the public health sector as to knowledge of climate change and its impact on disease change. These individuals are in position to only mediate the response to a new disease

but may act as a trusted conduit to timeously inform vulnerable communities most direly in need of such information.

Different forms of surveillance include:

- passive (from health facilities)
- active (disease-directed intentional gathering of data)
- civil registration (birth and death surveillance)
- verbal autopsies (interviews with next-of-kin to obtain cause of death)
- sentinel surveillance (using selected health care facilities that report more frequently or provide more detailed information, or animals to detect zoonotic disease patterns)
- disease registries (information on specific diseases that may not be captured on the death certificate)
- longitudinal demographic surveillance systems (population dynamic events are continuously monitored), and
- census data (population enumeration).

(Wilson and Anker, 2005: 203)

Disease surveillance is international in nature with intergovernmental organisations playing a crucial role: the WHO as mandated to coordinate the global surveillance while the International Health Regulations (IHR) provides the legal framework for sharing epidemiological information. Disease mapping using GIS and special statistical analyses improve surveillance. Acute-care networks use software for detecting known risks and unexpected events flagging any sudden increase in the number of cases presenting with a syndrome. Weather and climate surveillance are crucial since disease risk may be affected by climate and the information obtained is used to forecast and predict (Wilson and Anker, 2005).

2.5.4 Conclusion

A population can only assist itself in a dire situation if it knows what to do or has a keen adaptive capacity. If it has been prepared beforehand, its reaction will be even better and its chance of survival and/or recovery greater. In the case of humans, a supply of relevant

information relating to factors contributing to changes in disease patterns can significantly contribute to such adaptive capacity.

We need to take note of what we are doing to Earth's bio-geo-capacity (McMichael, 2014) and the impact of our behaviour on the ecosystems of which we are a part – where “natural corrective mechanisms are being overwhelmed” (Epstein, 2002). Policy makers need to take heed and make the required changes to bolster adaptive capacity and reduce vulnerability. The media must create awareness and ensure the public understand how human activities are impacting our existence.

Predictive models and early warning systems can perform a vital function in creating the awareness without creating an environment of panic or dismay. They serve to inform, prepare and preserve. **We are not alone sharing of the Earth's bounty and without those we share it with our existence would cease.**

2.6 Public Healthcare and Preparedness

2.6.1 Introduction

Public health is the science and art of preventing disease, prolonging life and promoting health through organised efforts of society. Public health activities may change but the goals remain constant: reduce the amount of disease, premature deaths and disease-related discomfort and disability in a population. There are four ethical principles upon which this rests: respect for autonomy (upholding human dignity and the rights of individuals), non-maleficence (no intentional harming – *first, do no harm*), justice (fair, equitable and impartial) and beneficence (doing good for others) (Ebi *et al*, 2005:4).

Sauerborn (2013) asked the following questions in his article entitled *Climate of uncertainty*: “Which diseases could proliferate? Which communities will be most vulnerable? How widespread will the impact be? And, perhaps most importantly, how should we react?” From the previous chapters and the literature review, it is clear that both communicable and non-communicable diseases will increase with change in climate, both directly and indirectly. The focus of this writing leans more toward infectious diseases – however, immunocompromised and ‘diseased’ individuals will be most at risk. Those suffering with non-communicable

(lifestyle) diseases such as diabetes, hypertension, hyperlipidaemia, obesity and cardiovascular conditions will face the effects of climate change differently and may in fact be more affected due to their compromised condition and ‘troubled’ immune system. Should we encounter an emerging or re-emerging infectious disease in a community suffering the ills of lifestyle diseases and poverty the ‘herd immunity’ concept will have no match against the infectious agent and this agent will proliferate and cause great harm (Ebi *et al*, 2005:7; McMichael, 2001b).

Vulnerability is defined in terms of the level of material resources, effective governance, public health infrastructure, access to effective local information and existing burden of disease (Ebi *et al*, 2005:2). The research carried out by Econex (2009) identified that South Africa is carrying a unique quadruple burden of disease with the greater proportion of resources going to non-communicable diseases and HIV/AIDS, leaving a gap, in financial and human resources, for, perhaps, effective treatment of infectious diseases (Econex, 2009). Health promotion has not been nurtured in Africa as a continent– this could be historic (colonial influence not ideally suited to indigenous local circumstances) or due to governmental regimes (Sanders *et al*, 2008). Regardless of the reason, time for change is overdue. Public health and the policies that govern it must be adapted to reduce vulnerability, enhance adaptation, improve predictions and understand decision-making processes (Campbell-Lendrum, 2009). The South African government committed itself to this end as documented in the NCCR Green Paper and White Paper. The papers both detail the policies required with regards to adaptation in the water, agriculture and human health sectors as well as mitigation in the energy, industry and transport sectors (DEA: 2010, 2011).

Adaptive capacity has been defined as the general ability to adjust to potential changes, take advantage of opportunities and cope with the consequences. The goal of public health is to reduce future population vulnerability to climate variability and change (Ebi *et al*, 2005:3). This can, however, only be achieved with knowledge of infectious agents, the changes that are happening to our climate, how these interact and how spread of disease can be prevented.

Prevention can only take place where knowledge of the very thing to be prevented is possessed. The knowledge spoken of must be available to the public and easily obtained. A powerful source in getting knowledge to the public is through the media. During disease outbreaks, the public follow media reports closely and often engage in social distancing to minimise contact

and avoid infection. Mummert and Weiss (2013) conducted research on the influence of the media on limiting emerging infectious disease outbreaks. It was clear that public health agencies and media working together can dramatically reduce the severity of an outbreak. Their models showed that for short-term outbreaks, the most effective strategy to reduce infections is to provide information as early as possible (BBC WST, 2010).

2.6.2 Assessing knowledge base

Basic indicators of a population's health status are necessary and should be available. Low-cost data from primary health care facilities can be collected and collated – specifically in sentinel populations to monitor disease incidence and prevalence providing a sensitive index of impact (McMichael, 2001b). Individuals specifically afflicted by the change, such as those whose homes are destroyed by flooding and others affected by the loss of wildlife, link the changes to national issues. Climate change is seen as a 'green' issue over which only the wealthy can afford to be concerned and see no reference to the consequences of climate change on food yields, tourism and migration. As a result, there is no drive for these individuals to alter their lifestyle, specifically so when no leadership from government or the private sector is forthcoming. Opinion leaders consider climate change as a remote threat and no action need be taken as the impact thereof is not yet recognised and does not touch their everyday lives (WST BBC, 2010).

With this backdrop it is noted that knowledge is key to adapting to climate change but such knowledge is lacking amongst the general public. In South Africa the state of knowledge amongst individual citizens about climate change is limited and most local populations do not consider climate change as having any relevance to the country, or even the continent. The Water Research Commission (WRC) acknowledges that knowledge is the **cornerstone of SA's adaptation to climate change** and has redefined its research portfolio on climate change over five years (the article was published in 2009). In 2014, the WRC reported that South Africa has limited capacity for preparedness and coupled with the variable climate makes the country vulnerable to climate change and its effects (WRC, 2014). A decision-support framework for an adaptive management strategy has been set up to assess and modify water services delivery.

And what of healthcare? Robinson and Clark (2008) examined the plight of health care in the context of health worker migration. Wealthier nations attract health workers from poorer

nations as these professionals seek a better life. And they have a right to emigrate in search of a better life. However, their country (the source country) also has a right to good quality health provided by quality health care professionals. Two fundamental rights that continue to be a point of discussion and policy quandary, especially since the source country is usually of the world's poorest and can little afford loss of skilled professionals. It is therefore important to find ways to assist these poorer countries strengthen and increase their health system. South Africa (SA) has a bilateral agreement, a Memorandum of Understanding (MOU), with the United Kingdom (UK) aimed at strengthening the South African health system by reducing the loss of health workers to the UK. This is not always met with satisfaction as it limits employment opportunities. Canada is a favourite destination for many health professionals and SA has lost a number of physicians to that destination country. Consequently, SA has 'poached' health workers from other African states in order to fill the quota required to manage the large number of medical patients.

The public health environment is one of low resources and high demand. A mix in non-local health workers and a system experiencing strain, plus a lack of knowledge of climate change contribute to systemic vulnerability. As Yohe and Ebi (2005: 20-26) explain, public health vulnerability involves the non-permanency of public advances and the deterioration of public health infrastructure that results in return of adverse health outcomes. Adaptive capacity within health care becomes of critical importance and the IPCC hypothesizes that this involves a series of determinants such as technological options for adaptation, availability and accessibility of resources, human and social capital, competent and credible decision makers capable of managing information processes and embracing public attribution.

Considering the history of malaria in Africa, it remains a major threat, specifically to the sub-Saharan region. Land use change has increased malaria transmission. Swamp cultivation has increased the temperature of the water, thereby increasing the potential for breeding of disease vectors and pathogens. Deforestation increases the rate of parasite development within the mosquito. Githeko and Shiff (2005) state that Africa cannot currently cope with the burden of malaria and the adaptive capacity of its populations is low. Globalisation will further impact Africa due to the low priority for local social development (Githeko and Shiff 2005: 130).

Wilson and Anker (2005: 192) discussed public health disease surveillance and state that "public health surveillance has been defined as 'the continuing scrutiny of all the occurrence

and spread of disease that are pertinent to effective control’’. The collection of health and disease information together with the interpretation and distribution of the information to policy decision makers is an important outcome of surveillance. Surveillance is beneficial to analysing climate-disease links and improving the capacity to respond to weather extremes and climate variability. Data obtained from the surveillance can be shared with the public. At the time of writing, the authors indicated that there were no accepted rules and regulations for gathering surveillance data and the approach varies from one country to another. Costs and diagnostic availability determine the type of surveillance a country can enter into. Institutional infrastructure is crucial to adaptive capacity.

Health workers must recognise that changes in weather and climate may pose a threat to public health. Knowledge of disease patterns among different social and ethnic groups allows for comparisons to be made in recognition of lifestyle and behaviour. As indicated above, surveillance data are obtained passively from health facilities, actively from intentional data gathering, civil registrations, autopsies – interviews with next-of-kin, sentinel surveillance, diseases registries, demographic surveillance data and census data. Disease surveillance is international in nature with intergovernmental organisations working together. Weather and climate surveillance is crucial since disease patterns are affected by climate; the information obtained is used for forecasting and predicting (Wilson and Anker, 2005).

If development is a more economically viable means of reducing the impact of climate-induced disease such as malaria as opposed to emission abatement (Tol, 2008) it becomes apparent that climate will continue to change and will continue to affect natural systems and human health. The challenge continues in that managing human activities is even more difficult than regulating emissions (Sauerborn, 2013). Education and knowledge is needed.

Table 2-6: Six reasons to adapt to climate now (Smith *et al*, 1996)

Six reasons to adapt to climate change now
1. Climate change cannot be totally avoided
2. Anticipatory and precautionary adaptation is more effective and less costly than forced, last-minute, emergency adaptation or retrofitting
3. Climate change may be more rapid and more pronounced than current estimates suggest and, thus, unexpected events are possible
4. Immediate benefits can be gained from better adaptation to climate variability and extreme atmospheric events
5. Immediate benefits also can be gained by removing maladaptive policies and practices
6. Climate change brings opportunities as well as threats. Future benefits can result from climate change

Public health workers are for the most part respected in their communities and have a stronghold on changing behaviour or at least encouraging change. The knowledge base of these professionals and sensitivity toward the impact of climate change on human health should be at the forefront of public health policy, research and education programmes. Media must work closely with public health officials in publicising the information and influencing the public to acknowledge the need for change.

2.6.3 Assessing ways to improve preparedness

Adoption of adaptive measures: **“To prevent disease, we increasingly ask people to do things that they have not done previously, to stop doing things they have been doing for years, and to do more of some things and less of other things. Although there certainly are examples of successful programs to change behaviour, it is clear that behaviour**

change is a difficult and complex challenge. It is unreasonable to expect that people will change their behaviour easily when so many forces in the social, cultural and physical environment conspire against such change” – Institute of Medicine Health and Behaviour: The Interplay of Biological, Behavioural, and Societal Influences (Ebi *et al*, 2005:4).

Knowledge and adaptive capacity are critical in preparing for a potential change that may be detrimental to the existence of inhabitants on the Earth. Tremendous advances have been made in medical technology and treatment regimens worth billions in currency but we still fail the war against microbes; not for lack of trying, but for lack of empowering those most vulnerable with knowledge, failing to protect and preserve the natural constraints of disease (McMichael, 2011) and refusing to relieve the stress we have placed on the natural corrective mechanisms (Epstein, 2002).

Adaptive measures and improved adaptive capacity will be the only way to avert the real damage climate change-induced infectious diseases may cause to population well-being and public health, especially since the abatement of emissions and human behaviour change are not forthcoming. In 1996, Smith *et al*, gave six reasons to adapt to climate change (see table 2-6). The urgency to adapt is even more apparent now, nineteen years later.

In 2012, Ebi, Lindgren, Suk and Semenza discussed **Adaptation to the infectious disease impacts of climate change** and included determinants of climate change adaptation (see figure 2-2), guidelines on conducting an adaptation assessment as well as some examples of health adaptation assessments.

Policies and programmes required to control the risk of climate-sensitive infectious diseases requires basic health care functions. These functions are listed as including surveillance and interpretation of data, investigation and response, regulations, **education**, partnerships and research. Surveillance is labelled the core activity; yet surveillance requires acknowledgement of the existence of that which is to be surveyed and acknowledgement is bred from knowledge.

Assessments of both vulnerability and adaptation aim to identify where change in current and planned programmes is required and what opportunities exist for new policies and control measures. The main steps are identified as:

1. Evaluating effectiveness of current policies and controls;
2. Identifying options to manage health risks;
3. Evaluating and prioritising options;
4. Identifying resources required;
5. Developing programmes to ensure continued effectiveness

Nine of the 27 European Union countries have conducted an adaptation assessment of the impact of climate change on health. Fifteen of the EU countries plan to change their current vector-borne disease surveillance and control programmes. Significantly, only 5 countries consider the current surveillance as adequate (Ebi *et al*, 2012).

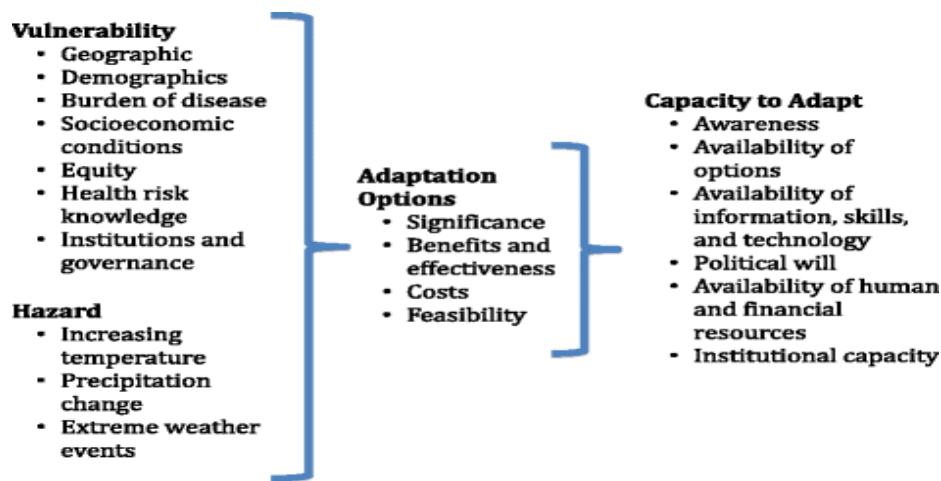


Figure 2-2: Determinants of climate change adaptation (Courtesy of Ebi *et al*, 2012)

Smit and Pilifosova (2001) describe adaptation as an *adjustment in ecological, social or economic systems in response to actual or expected climate stimuli and their effects or impacts*. Adaptive capacity is defined as *the potential or ability of a system, region or community to adapt to the effects or impacts of climate change*. A system, region or community's ability to adapt is dependent on certain requirements not always in place in vulnerable areas:

1. A stable and prosperous economy;
2. Access to technology;
3. A central government that delineates the roles and responsibilities of implementation;
4. A means to distribute information as well as discuss;
5. Governing of allocation of, and access to, resources;

6. Protecting existing systems showing a high degree of adaptive capacity – such as traditional ecological knowledge^{†††}.

Should the above requirements not be met, though, a system, region or community can still adapt significantly in order to reduce the impacts of climate change. The deterrent will be the aversion to change. Adapting is tantamount to changing. Adapting just gives the impression that minimal will be required on the part of the individual or the community as a whole. In order to improve preparedness, we will need to change: the way we behave and the way we view our behaviour, the way we impact on our environment and the respect we have for it.

2.6.4 Conclusion

Humans tend to place so much emphasis on what we don't have without accepting what we do have – the ability to cherish life, our own and that of others, both human and non-human. Most importantly, leaders need to provide knowledge to the community, since without knowing something is coming, one cannot prepare for its arrival. Government has the responsibility of caring for its citizens and enabling the realisation of their constitutional rights. The South African Department of Environmental Affairs in the NCCR Green Paper and White Paper has documented government's role in assisting and protecting its citizens. The papers were written in 2010 and 2011, respectively, with a pledge documented in the White Paper that within two years a draft National Climate Change Response Monitoring and Evaluation system will be available (DEA: 2010, 2011). In 2013, a draft was published, but has this filtered down to create public awareness and has government implemented the guidelines? (Harries and Dalglish, 2013).

It is acknowledged that there is a lot of uncertainty, but it must be noted that public health care will always be required and will always need improvement, innovation, government attention and resources. Globalisation, urbanisation, pressure on natural systems, population growth and over-crowding place strain on the health of individuals and the effectiveness of the public health services. Lack of acknowledging that our behaviour has a significant role to play and

^{†††} Bark from the Leadwood tree, a protected species some of which may be found at Sabi Sabi, is a bush medicine used to treat bilharzias (schistosomiasis) (Sabi Sabi, 2012)

government has an important task of educating the public further weakens what public health can do for the health of the public.

The International Meeting on Emerging Diseases and Surveillance (IMED) organised by the International Society for Infectious Diseases in Vienna 2009 included a presentation by Diarmid Campbell-Lendrum, published by the WHO, entitled **Climate Change and Emerging Diseases: What kind of information will help save the most lives?** addressing public health policy. One of the slides was labelled: “In long-term, reducing climate change is necessary to protect environmental determinants of health”. Three graphs were presented on the slide: one of **average glacier thickness change**, one of **sea level change**, and one of **extinctions per thousand species per millennium**. Another slide tackled the short-term: “In short-term, best protection is to address causes of vulnerability”. Statistics on solar radiation, monthly mean levels of CO₂, global land-ocean temperature and DALY measurements comparing temperature and admission for diarrhoea were given. The message was clear – we are not alone and need Earth’s natural resources to protect us so that we may function and survive in a healthy way. This takes responsibility but requires knowledge.

The following was identified as the philosophy of a new research agenda:

- “Less of climate change as a stand-alone threat to health, more on placing it within the context of existing health challenges;
- Less on disease projections for the late 21st Century, more on current decisions that will build long-term resilience;
- Less on pure risk-assessment, more on identifying cost-effective interventions, and maximising health co-benefits of mitigation;
- Shorter wish-lists, more on building capacity to address a few key issues, especially in developing countries”.

(Campbell-Lendrum, 2009)

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Research Design

The research was designed in such a way that data were collected from healthcare workers in three different South African provinces, Limpopo, Mpumalanga and Kwa-Zulu Natal, areas known to have a sub-tropical to tropical climate and rich, abundant store of fauna and flora. The data collected are presented in the form of tables and figures.

3.1.1 Research Method

Applied research is the pursuit of knowledge in order to provide answers or determine a problem or need and is not easily reduced to numbers (Remler and van Ryzin, 2011: 517). This research does, however, relate to the social world specifically to the behaviour of people. The qualitative approach used in this research method includes both closed- and open-ended questionnaires with the aim of obtaining information / knowledge to satisfy the investigation: climate change and its impact on healthcare provision in South Africa. Descriptive statistics will be used to describe the data collected.

Close-ended questionnaires were used to gather primary data from South African Red Cross Society (SARCS) counsellors working closely and under the umbrella of the Department of Health. These trained individuals come into direct contact with community members visiting the local clinics. The counselling given by the counsellors relates specifically to HIV/AIDS but an astute counsellor will listen to the patient and be aware of other health or social challenges experienced.

Three provinces were selected, based on their sub-tropical to tropical climate:

Limpopo, the name carrying the meaning strong gushing waterfalls, borders the countries Zimbabwe and Botswana as well as the South African provinces Mpumalanga, Gauteng and North West. Limpopo has a high level of poverty with 74.4% of its population living in tribal or traditional areas. It is known for its Waterberg biosphere which has been designated by UNESCO as a Biosphere Reserve made up of dry deciduous forest, known better as bushveld. Mpumalanga, the place where the sun rises, lies along the eastern portion of South Africa north of Kwa-Zulu Natal, bordering the countries Swaziland and Mozambique. Along the north, it

borders the province Limpopo. Mpumalanga makes up 6.5% of the land area in South Africa. The Drakensberg escarpment lies within the province bringing about a variety of biomes. In the west, high altitude grassland are common with sub-tropical conditions in the low altitude lowveld with rocky outcrops. In the east of the province savannah conditions prevail with regions of forest. The well-known Kruger Park lies in the south. The lowveld is considered sub-tropical and frost free with the Highveld being cooler with severe frost.

Kwa-Zulu Natal, *the garden province*, has a lowland, midland and mountainous region. The lowland is along the coast with the bordering Indian Ocean and experiences sub-tropical conditions. The midlands are a hilly plateau with moist grasslands and the Drakensberg and Lebombo making up the mountainous area; the Drakensberg in particular is made up of Alpine grassland. Along the north of the province, the biome is mainly moist savannah.

UNESCO has labelled the iSimangaliso Wetland Park and Ukhahlamba Drakensberg Park as world heritage sites. These are wetland areas and important destinations for migratory species.



Figure 3-1: Map of South African provinces, obtained from Google images

The groups selected to participate in the research indicate a specific cross-section of the population and do not represent the views of the general public.

A meta-analysis of existing data and literature provides important background information to assist with the hypothesis: will climate change affect the distribution of tropical and sub-tropical disease vectors and agents moving them into altered temperate regions favourable now for feeding and reproduction?

3.1.2 Fieldwork Procedures

- ✓ A field visit to Mokopane in the Limpopo province to physically meet with the SARCS members and distribute the questionnaires. Three days were spent visiting the local clinics and the local hospital, meeting the staff, becoming familiar with the area and sitting with some of the participants as they completed the questionnaires;
- ✓ A meeting in Gauteng with a SARCS manager for the Mpumalanga province, who collected, distributed and coordinated the completion of the questionnaires;
- ✓ Electronic communication with the SARCS provincial manager for the Kwa-Zulu Natal province, who received, distributed and coordinated the completion of the questionnaires.

3.2 Population and Sampling Procedures

3.2.1 Sample Design and Criteria

South Africa has nine provinces and over 1,600 clinics servicing the public since 1994, according to SouthAfrica.info. Out of the nine, three provinces were selected for this research: Kwa-Zulu Natal (KZN), Limpopo and Mpumalanga specifically since their climate is favourable for familiar vector-borne diseases such as malaria and the more unfamiliar trypanosomiasis.

A field trip to Mokopane in Polokwane contained in the Limpopo province of South Africa during a sweltering November in 2013 started the questionnaire collection process. Over three days a total of 8 clinics and the main public hospital were visited. A total of 58 completed questionnaires were obtained from the field.

The collection process for Mpumalanga and KZN was notably different. For Mpumalanga, a representative from the SARCS graciously made himself available to receive the

questionnaires. These were then distributed amongst the counsellors. Once complete, the questionnaires were collected and returned. A total number of 35 responses were received.

For KZN, the sharing of information was purely electronic, specifically email. The surface area serviced by the SARCS in that province is very wide and the terrain not altogether vehicle friendly. A field trip would not have been possible. The manager who assisted was also not able to go to each area to deliver the questionnaires and also relied on modern technology to send and receive the completed documents. As a result, only 8 responses were completed and returned. None of these contained demographic data.

Overall, a total number of 101 questionnaires were received.

3.3 Instruments

The instrument used in the research was a close-ended questionnaire (Appendix E).

The close-ended questionnaire is used for the primary healthcare workers of the SARCS as part of the investigation of climate change and its impact on healthcare provision in South Africa. The research will investigate the knowledge base and awareness of primary healthcare workers with regards to emerging infectious diseases and neglected tropical diseases in South Africa as a result of climate change in order to measure the need for education and funding based purely on the opinions and perceptions of the participants.

3.3.1 Description of questionnaire

The close-ended questionnaire covers 33 variables spread over:

- A. Climate Change (10 questions)
- B. Climate Change and Human Health (10 questions)
- C. Primary Healthcare (5 questions)
- D. General Information about the Clinic (8 questions)

The questions provide for between 5 and 9 response options each. Only one response is required per question. The responses from 101 questionnaires were tabulated on an excel spread sheet and pivot tables and figures were used to analyse the data collected.

In some cases, more than one response per question was completed. The responses were either ordinal or categorical. Ordinal variables do not have distributional features like means and variances making statistical analysis non-parametric.

The type of questions used for data collection was selected specifically to obtain the healthcare workers' perception of climate change and public healthcare provision. The findings were to give an indication of perception with regards to the impact climate change may or may not have on healthcare and do we have provisions in place to manage such an impact.

3.3.2 Reliability

The rule of thumb for sample size is approximately 10 variables per response for significant statistical findings. The survey is not invalid in that the sample size was not reached. The analysis thereof would be descriptive statistics of qualitative data.

The survey questionnaire used is non-repeatable as it is qualitative and subjective. The findings will, therefore, be qualified. The questions were selected to determine awareness amongst the healthcare workers in order to investigate the impact of climate change on healthcare provision and whether training and education is required to ensure healthcare workers' preparedness to assist with adaptation and resilience in the event of changes in disease patterns.

3.3.3 Validity

Responses to the questions were required to be honest and genuine. No pressure was applied on the participants and they were allowed to discuss the questions amongst themselves.

The phenomena the findings are intended to represent is climate change and the impact on the provision of healthcare in South Africa. The questions were posed to eliminate any ambiguity in the question itself and the terms used. It is noted that a few terms were not familiar to the participants and posed a hurdle in answering freely and honestly.

Participant anonymity was emphasized and no names or personal information was requested from the participants.

Participants may select the highest or lowest possible score if an ulterior motive is involved. These have been counted separately and may or may not reflect the actual feeling behind the response. Limitations of a simple agree or disagree response may have eliminated these extremes.

3.4 Data Collection and Analysis

A brief description of how data were collected and the number of responses per province is presented below, together with a summary of the findings.

3.4.1 Data collection process

This research study was based on primary research. Primary research was done in the form of primary data collection to determine the awareness of primary healthcare workers as to climate change and the effect, if any, on human health. The output of the research is meant to give insight into the preparedness of primary healthcare facilities in dealing with the potential increase in infectious diseases brought on by climate change and the impact on health provision.

The questionnaire was in English with the aide of a SARCS representative to assist with explaining the requirements should these not be understood.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

The aim of this study is to determine the level of awareness primary healthcare workers have on climate change and the potential effect on infectious diseases. The specific objective is to determine the level of climate change awareness and the impact climate change can have on healthcare provision. The target group for the questionnaire was members of the South African Red Cross Society (SARCS) working together with the department of health at local clinics in Limpopo, Mpumalanga and Kwa-Zulu Natal. In addition, a meta-analysis to magnify the relationship between climate change and infectious disease distribution and transmission patterns with a view to adding insight into potential future events and ensuring that we realize the importance of starting to prepare now for what may come by way of education, training and adaptation.

4.2 Results Presentation

The variable used in the study are summarised in the form of tables and figures. The results obtained from the questionnaire are presented for descriptive and inferential analysis.

Table 4-1 shows the number of respondents per province. In all three provinces, the questionnaires were administered with the help of senior SARCS members.

Table 4-1: Data collection as per province

Name of province where the data was collected	Number of respondents
Limpopo	58
Mpumalanga	35
Kwa-Zulu Natal	8
<u>Total</u>	101

Permission was granted by the SARCS to collect data from their counsellors at the various local clinics (See Appendix B). The data were collected in the form of the close-ended questionnaire. The questionnaire was anonymous and no personal data regarding identity numbers, names or addresses were asked for. The questionnaire, Appendix E, was structured in such a way that one question followed on from another. As indicated above, there were four sections each dedicated to a different aspect of the study:

- A. Climate Change (10 questions)
- B. Climate Change and Human Health (10 questions)
- C. Primary Healthcare (5 questions)
- D. General Information about the Clinic (8 questions)

4.2.1 Data analysis

The responses were captured on a spread sheet and using pivot table approach, frequency of responses within specific categories was obtained.

Limpopo

Demographic data analysis:

There were a total of 58 participant responses from Limpopo SARCS with a strong female presence – 91% (n=53) of participants are female. The ages of the participants range between 25 and 39 years with the highest clusters between 25 and 29 years (22%; n=13), between 30 and 34 years (19%; n=11) and between 35 and 39 years of age (24%; n=14).

The formal education level of the participant's points to an almost equal distribution between those with high school and /or matric (45%; n=26) and those with a post-matric qualification (46%; n=27). Of the remaining 5 participants, 2 did not indicate their education level, 1 indicated no formal schooling, 1 indicated a pre-primary schooling level and 1 indicated a primary school level.

Work experience at the current clinic indicates reasonable stability: 36% (n=21) of the participants have been working at their current clinic for between 3 and 5 years, while 33% (n=19) have been working at their current clinic for between 6 and 10 years and 17% (n=10)

have been at their current clinic for more than ten years. This is important as it creates stability and trust within the local community and with the counsellors. The community members feel safe to discuss health problems and concerns with these individuals with whom they have had very personal, connected conversations with [with the right training, these counsellors can be radar for unusual medical complaints and uncannily pre-empt epidemics].

Working hours range from between 6 to 10 per day (91%; n=53), possibly with the majority falling within the 8 hour zone. Five per cent (n=3) of the participants indicate that they work longer than 10 hours per day. The relevance here is that the counsellors are not too stretched with regards to time spent with patients, not rushing through the counselling and potentially missing important hints to illness and discomfort that may be mentioned.

Clinic data analysis:

The majority of responses reveal that the clinics see more than 80 patients per day (48%; n=28) with 22% (n=13) responses indicating that between 61 and 80 patients are attended to per day. Of those patients seen, the majority are women: 57% (n=33) of the responses indicate that the patients are mainly women, with 36% (n=21) of the responses indicating that the numbers between men and women are equal.

Patient ages range from babies and toddlers to young and old adults as noted by the responses: 45% (n=26) of the participants gave more than one response to the question.

Clinics are situated strategically within each community with 57% (n=33) of the responses indicating that patients must travel from 1 to 2 kilometres to get to the clinic in predominantly hot and dry conditions (41%; n=24).

Questionnaire response analysis

The three sections of the questionnaire under consideration are:

A. Climate Change

Obtaining responses regarding climate change provides insight into the understanding and opinion of the counsellors – whether they believe it is a cause for concern and is something real that will affect lives and by extension health care provision.

Discussion:

B. The Effect of Climate Change on Human Health

Drilling down, this section focuses on infectious diseases and climate, once again drawing out opinions and perceptions.

C. Primary Healthcare

The responses here are of great importance as they provide insight into opinions regarding sufficient resources and disease monitoring.

The responses obtained provided the following insight:

Section A: Climate change

The majority of the participants (87%; n=50) agree that our climate is changing. Of these responses, 34% (n=20) strongly agree with the statement. Equally so, almost all the respondents (99%; n=56) agree that our weather is changing, with 23 respondents strongly agreeing with the statement. The separate concepts of climate and weather are recognised by half of the participants (n=29) with a small minority (n=3) indicating that they do not know. Under a third of the respondents (n=17) agreed that climate and weather are the same. It is agreed by many of the participants (75%; n=43) that climate involves rainfall and most (91%; n=52) agree that climate change can affect human health.

With regards to ozone depletion, 15 of the participants do not know if ozone depletion is affecting daily temperatures, while 57% (n=32) agree that it does and only 5 respondents disagree. With regards to whether global warming is because of ozone depletion, 24 responded that they do not know while 23 agree with the statement. With regards to human-induced global warming, 9 disagree with the concept while 32 agree with man's involvement (11 strongly agree).

Understanding of the greenhouse gas effect represents 28 of the responses, with 18 not knowing and 6 disagreeing that greenhouse gases cause global warming. There is majority consensus that increased levels of carbon dioxide in the air are due to human activities – 44 agree, with only 6 disagreeing.

Section B: The effect of climate change on human health

Eighty eight per cent (n=51) of participants agreed that diseases are influenced by changes in climate with 45 agreeing that diseases carried by insects will increase if the Earth's climate changes; 5 disagree and 8 do not know. A smaller number of participants (46%; n=27) agree that diseases carried by insects are called vector-borne diseases with 38% (n=22) indicating that they do not know (this could be due to the vernacular used). Water-borne diseases are better known and 65% (n=38) of responses are in agreement that diseases carried by water are water-borne diseases, with 26% (n=15) indicating they do not know and 9% (n=5) disagreeing. With regards to the infectious nature of vector- and water-borne diseases, 67% (n=39) of the participants agree with the statement while 21% (n=12) indicate that they do not know and 10% (n=6) disagree. Of significance, is that 90% (n=52) of participants agree that diseases can travel with people while 7% (n=4) disagree.

Zoonosis, forming part of question seven, was perhaps not understood resulting in 46% (n=27) of the participants responding that they do not know if this was a disease passed from an animal to a human and 46% (n=7) responding in agreement.

With regards to tropical diseases and the preferred climate, 57% (n=33) of the participants agree that tropical diseases prefer warm and wet climates, while 34% (n=20) do not know and 4 disagree. Seventy six per cent (n=44) of participants agree that malaria is a tropical disease with 10% (n=6) disagreeing and 10% (n=6) indicating that they do not know.

Finally, 94% (n=55) of the participants agree that malaria is a threat to public health and only 3% (n=2) disagree.

Section C: Primary healthcare

In Limpopo, 77% (n=45) of the participant responses are in agreement that they have sufficient resources to assist with their job; 12% (n=7) disagree and 10% (n=6) do not know. Patients are referred when they are unable to assist as confirmed by 95% (n=55) of the responses. Of interest, is that 98% (n=57) of the participants are in agreement that there are changes in the diseases they see. Eighty six per cent (n=50), agree that there is an organisation monitoring these changes in disease with 100% (n=58) agreeing that more is needed to improve healthcare (25 strongly agreeing).

Mpumalanga

Demographic data analysis:

A total of 35 participant responses in Mpumalanga SARCS and indicate a strong female presence as in Limpopo but the percentage is lower – 74% (n=25) of participants are female. The ages of the participants range between 25 and 54 years with clusters of 28% (n=10) between 25 and 29 years, 20% (n=7) between 40 and 44 years and 14% (n=5) between 50 and 54 years of age. Notably, this indicates a large younger component with a close in number older component of participants.

The formal education level of the participants indicates that 40% (n=14) have high school and /or matric and 49% (n=17) have a post-matric qualification. This is encouraging as it indicates an academically qualified group of healthcare workers.

The work experience of the participants in the Mpumalanga province clearly shows a strong stable component: 37% (n=13) have been working at their current clinic for more than 10 years, with 26% (n=9) working at the current clinic for up to 2 years and 9 of the participants having worked at their current clinic for between 3 and 5 years. As in Limpopo, this engenders stability within the community and the healthcare workers become familiar with the ailments of the community members – once again, making them important radar for unusual medical complaints.

The range of working hours lies in the majority between 3 to 10 hours per day with the majority (49%; n=17) working between 3 to 5 hours per day and 34% (n=12) of the participants working between 6 to 10 hours a day. The reason for the reduced working hours is not known.

Clinic data analysis:

Twenty one of the responses indicate that more than 80 patients are seen at the majority of clinics per day (60%) with 17% (n=6) responses indicating that between 41 and 60 patients are attended to per day and 14% (n=5) responses indicating that between 61 and 80 patients are seen per day. Of those patients seen the majority are women: 60% (n=21) of the participants indicate that the patients are mainly women with 31% (n=11) of the participants indicate that an equal number of men and women patients are seen.

With regards to patient ages 28% (n=10) of the participants marked all ages indicating a wide range from babies and toddlers to young and old adults. However, the majority of the remaining responses selecting the 26 to 35 year old grouping (23%; n=8) with (14%; n=5) selecting the 18 to 25 year old grouping.

The clinics are also situated strategically within each community and over 34% (n=12) of the responses indicate that patients must travel up to 2 kilometres to get to the clinic in predominantly hot, humid and wet conditions, 46% (n=16) of responses indicating this climate.

Questionnaire response analysis

The questionnaire is divided into three sections:

A. Climate Change

Obtaining responses regarding climate change provides insight into the understanding and opinion of the counsellors – whether they believe it is a cause for concern and is something real that will affect lives and by extension health care provision.

B. The Effect of Climate Change on Human Health

Drilling down deeper this section focuses on infectious diseases and climate; once again drawing out opinions and perceptions.

C. Primary Healthcare

The responses here are of great importance as they provide insight into opinions regarding resources and monitoring.

The responses obtained provided the following insight:

Section A: Climate change

In Mpumalanga, 94% (n=33) of the participants agree that our climate is changing (of which 54% strongly agree) and 91% (n=31) of the participants agree that our weather is changing (of which 60% strongly agree). A strong majority of the participants (74%; n=26) agree that climate and weather are the same with 23% (n=8) disagreeing. Ninety one per cent (n=32) of responses agree that climate involves rainfall and 91% (n=32) agree that climate affects human health.

With regards to ozone depletion, 66% (n=23) agree that days are warmer due to ozone depletion, with 20% (n=7) disagreeing. Twenty seven (77%) of the participants agree that global warming is due to ozone depletion, with 8% (n=3) disagreeing. A strong 80% (n=28) agree that global warming is caused by human activities (of that 46% strongly agree).

It is agreed by 66% (n=23) of the participants that the greenhouse gas effect is causing global warming while 23% (n=8) believe it does not and 11% (n=4) do not know. As to whether human activities increase levels of carbon dioxide, 86% (n=30) believe it to be so with 1 strongly disagreeing.

Section B: The effect of climate change on human health

A strong 86% (n=30) of participants agree that diseases are influenced by changes in climate with 86% (n=30) agreeing that diseases carried by insects will increase if the Earth's climate changes. A similar number, 83% (n=29) of participants, agree that diseases carried by insects are called vector-borne diseases with only 9% (n=3) indicating that they do not know (this could be due to the vernacular used). Water-borne diseases are well known and 80% (n=28) of participants are in agreement that diseases carried by water are water-borne diseases, with only 11% (n=4) indicating that they do not know and 9% (n=3) disagreeing. With regards to the infectious nature of vector- and water-borne diseases, 83% (n=29) agree with the statement and only 14% (n=5) disagree. Eighty eight per cent (n=31) of participant responses agree that diseases can travel with people.

Zoonosis, forming part of question seven, was understood resulting in 80% (n=28) of participants agreeing that this is a disease passed from an animal to a human. Only 11% (n=4) indicated that they do not know.

With regards to tropical diseases and the preferred climate, 91% (n=32) agreed that tropical diseases prefer warm and wet climates. Eighty six per cent (n=30) of participants, agree that malaria is a tropical disease with 9% (n=3) disagreeing.

Finally, 94% (n=33) agree that malaria is a threat to public health.

Section C: Primary healthcare

In Mpumalanga, 77% (n=27) of the participant responses are in agreement that they have sufficient resources to assist with their job with 23% (n=8) disagreeing. Patients are referred when they are unable to assist as confirmed by 97% (n=34) of the responses. Of note, is that 88% (n=31) of the participants agree that there are changes in the diseases they see with 88% (n=31) agreeing that there is an organisation monitoring these changes in disease. Ninety two per cent (n=32) responses, agree that more is needed to improve healthcare (69% strongly agreeing).

Kwa-Zulu Natal

Demographic data analysis:

No demographic data received.

Clinic data analysis

The majority responses indicate that the number of patients seen at the clinics ranges between 41 and 60 (50%; n=4) with all of these being female. The total responses received are only 8 so the percentages do not accurately define the reality. Patient ages are noted to be between 18 and 35 years old.

The responses indicate that the majority of patients must travel more than 4 kilometres to reach the nearest clinic in hot, dry and humid conditions (indicated by 50%; n=4) to warm and wet conditions (37%; n=3).

Questionnaire response analysis

The three sections of the questionnaire under consideration are:

A. Climate Change

Obtaining responses regarding climate change provides insight into the understanding and opinion of the counsellors – whether they believe it is a cause for concern and is something real that will affect lives and by extension health care provision.

B. The Effect of Climate Change on Human Health

Drilling down deeper this section focuses on infectious diseases and climate; once again drawing out opinions and perceptions.

C. Primary Healthcare

The responses here are of great importance as they provide insight into opinions regarding resources and monitoring.

The responses obtained provided the following insight:

Section A: Climate change

In KZN, with such a smaller group, the responses indicate 100% (n=8) agreement that our climate is changing and 100% (n=8) agreement that our weather is changing with 50% (n=4) agreeing that climate and weather are the same. All participants agree that climate involves rainfall and all participants agree that climate change can affect human health.

With regards to ozone depletion, 25% (n=2) of the participants said they do not know if daily temperatures or global warming are affected or caused by ozone depletion, while 50% (n=4) agree that they are affected. Five of the participants agree that global warming is caused by human activities.

With regards to human involvement, 75% (n=6) of responses agree that the greenhouse gas effect is causing global warming and 87% (n=7) agree that the increased levels of carbon dioxide in the air are due to human activities.

Section B: The effect of climate change on human health

In Kwa-Zulu Natal, 87% (n=7) of participants agree that diseases are influenced by changes in climate with 37% (n=3) agreeing that diseases carried by insects will increase if the Earth's climate changes; 50% (n=4) indicate that they do not know. Fifty per cent (n=4) agree that diseases carried by insects are called vector-borne diseases with 38% (n=3) indicating they do not know (this could be due to the vernacular used). Water-borne diseases appear to be less known and 50% (n=4) of responses do not know if diseases carried by water are water-borne diseases while 38% (n=3) agreed. With regards to the infectious nature of vector- and water-

borne diseases, 25% (n=2) agreed with the statement and 50% (n=4) do not know. Seventy five per cent of participant responses (n=6) agreed that diseases can travel with people.

Zoonosis, forming part of question seven, was perhaps not fully understood resulting in 50% (n=4) of participants agreeing that this is a disease passed from an animal to a human with 38% (n=3) indicating that they do not know.

With regards to tropical diseases and the preferred climate, 62% (n=5) agree that tropical diseases prefer warm and wet climates, while 38% (n=3) do not know. Fifty per cent (n=4) of participants agree that malaria is a tropical disease with 38% (n=3) disagreeing.

Finally, 50% (n=4) agree that malaria is a threat to public health with 38% (n=3) indicating that they do not know.

Section C: Primary healthcare

In Kwa-Zulu Natal, 38% (n=3) of the participant responses are in agreement that they have sufficient resources to assist with their job, with 38% (n=3) disagreeing. Patients are referred when they are unable to assist as confirmed by 75% (n=6) of the responses. Seventy five per cent (n=6) of the responses agree that there are changes in the diseases they see with 50% (n=4) agreeing that there is an organisation monitoring these changes in disease and 25% (n=2) indicating that they do not know. Just less than 88% (n=7) agree that more is needed to improve healthcare (3 strongly agreeing).

Demographic data

Demographic data was not obtained from Kwa-Zulu Natal. The presentation of demographic data represents 93 participants, from Limpopo (58) and Mpumalanga (35).

Figures 4-1 and 4-2 below reflect the age groups and gender of the participants indicating a predominately female group of counsellors in both Limpopo and Mpumalanga. Of significance is the age group: in Limpopo, the majority fall within the 35-39 age group (24%; n=14), but closely followed by the younger 25-29 group (22%; n=13). In Mpumalanga, the 25-29 age

group far exceeds the 35-39 age group (28%; n=10 versus 6%; n=2) and is followed by the older 40-44 and 50-54 categories (20%; n=7 and 14%; n=5).

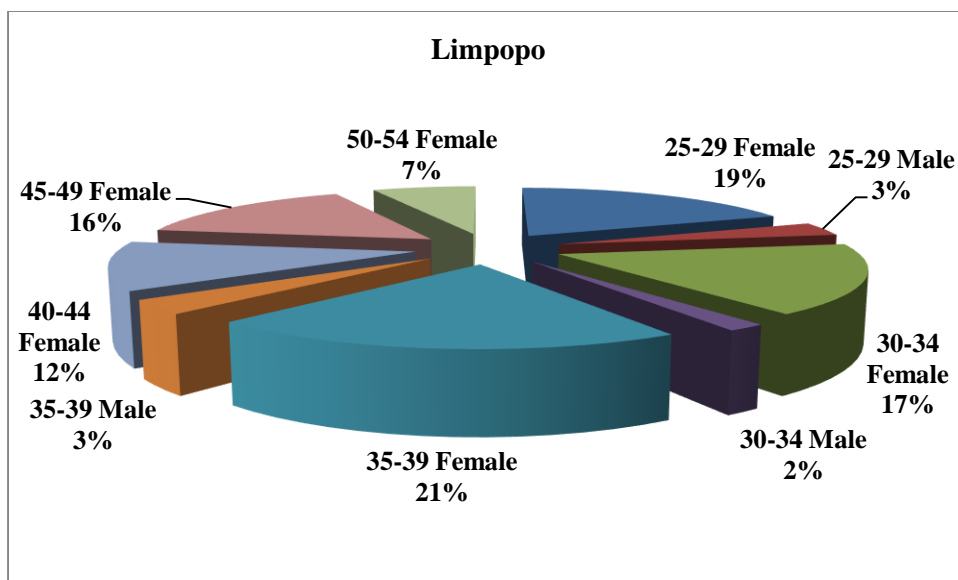


Figure 4-1: Limpopo age and gender

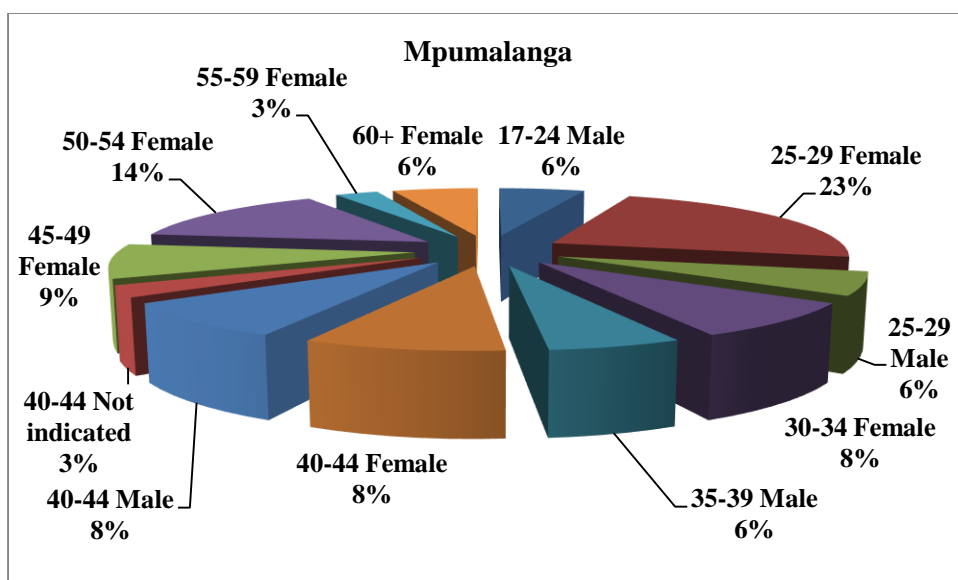


Figure 4-2: Mpumalanga age gender

The education level, as shown in the figures below, within both provinces indicates a strong leaning toward tertiary education, specifically among the counsellors in Mpumalanga.

Comparing that with the age group, it is significant that the tertiary education is amongst the younger category of 25-29. The democracy in South Africa has seen tremendous changes with regard to education and the findings of this survey are encouraging. It does, however, place pressure on government to direct funding to healthcare and education in support of the positive changes democracy has brought to these essential sectors. The figures below, 4-3 and 4-4, clearly show the greatest number of post matric participants are within the 25-29 age group.

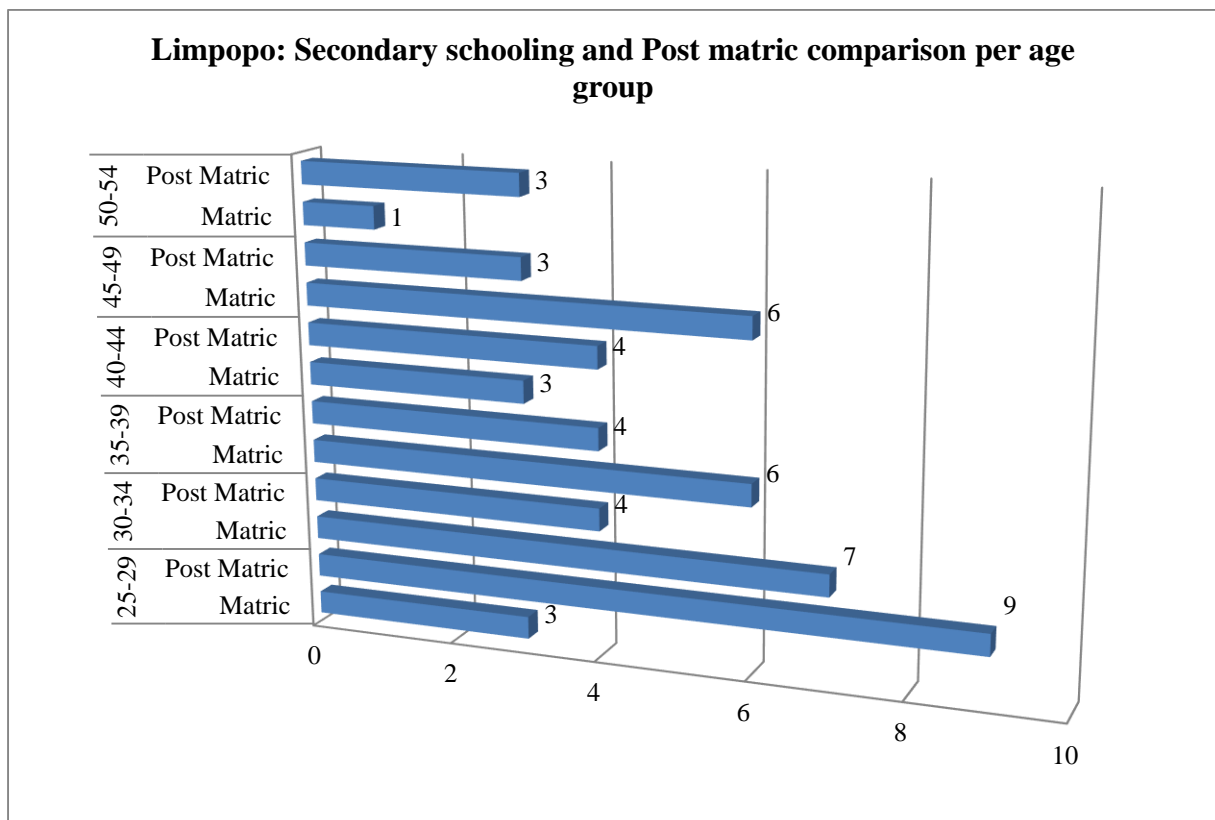


Figure 4-3: Limpopo age and education

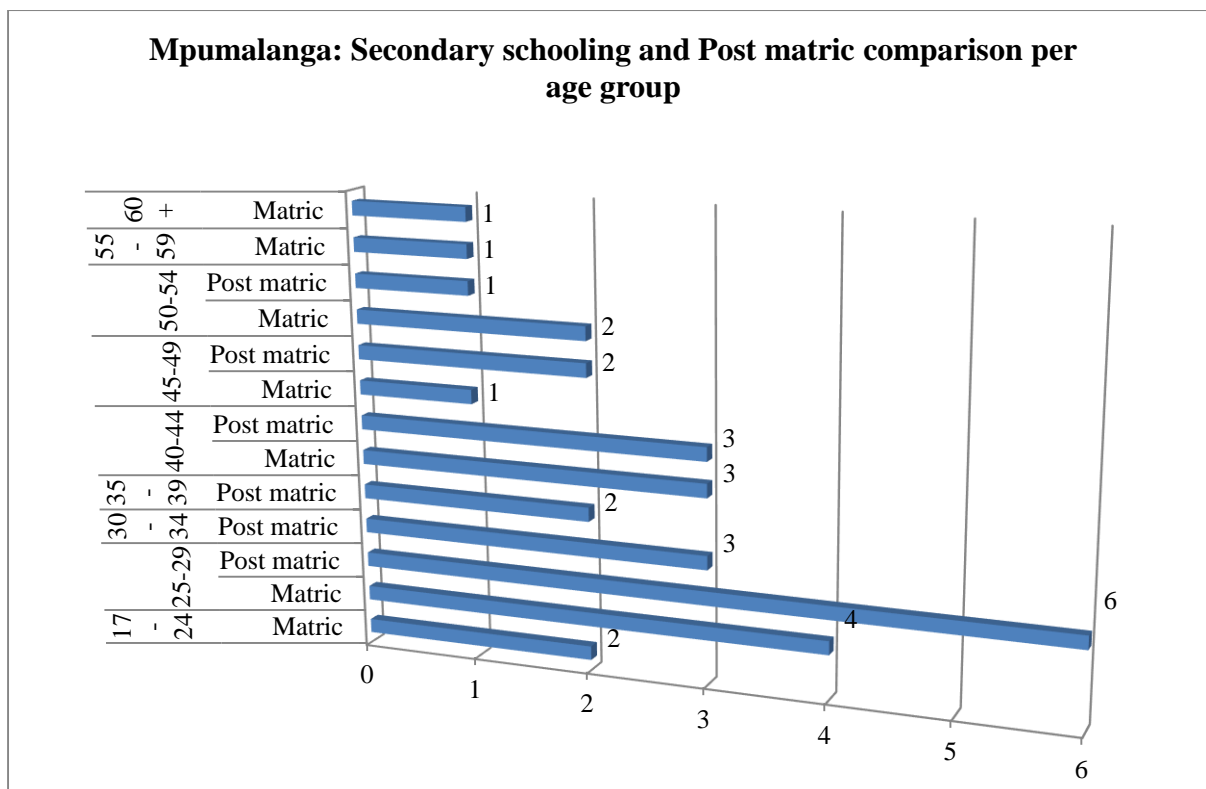


Figure 4-4: Mpumalanga age and education

The distribution of the number of working years a participant has spent at their current clinic clearly indicates the stability in both provinces with the majority of working years being between 3 to 5 and 6 to 10 in Limpopo with 10 plus years being the majority in Mpumalanga. This represents stability and familiarity within the community and the local clinics.

This is illustrated in the figures below, 4-5 and 4-6.

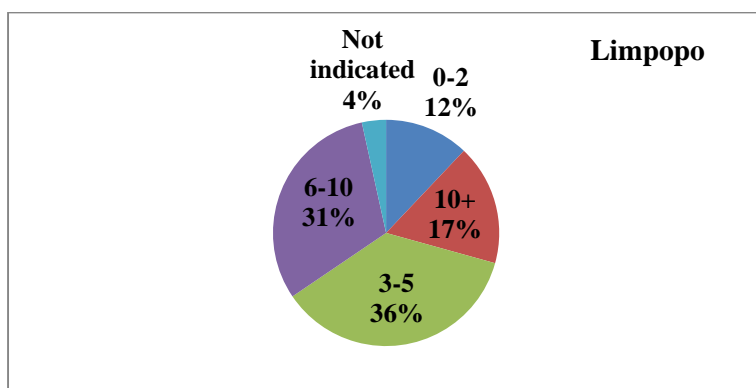


Figure 4-5: Limpopo working experience

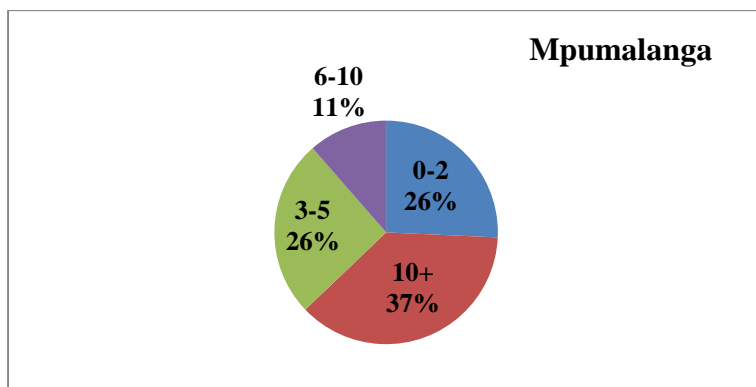


Figure 4-6: Mpumalanga working experience

The number of hours spent at the clinic per day by each participant is shown in Figures 4-7 and 4-8. In Limpopo, 91% (n=53) of the participants indicate that they work 6 to 10 hours per day, which fits in with a normal 8 hour day.

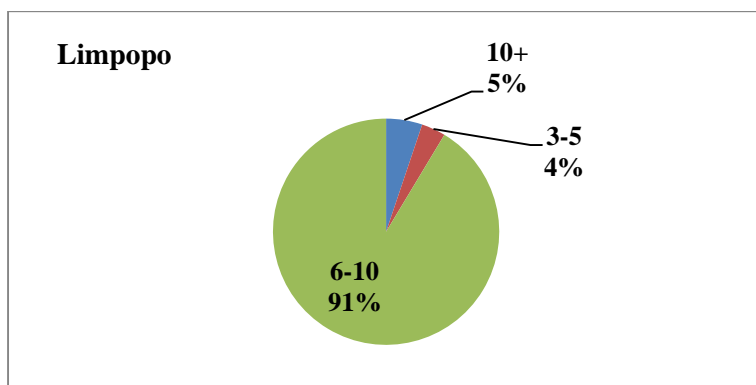


Figure 4-7: Limpopo working hours

In Mpumalanga, the majority (49%; n=17) work 3 to 5 hours per day. The reason for the reduced hours is not known. This is closely followed by the 6 to 10 hour category (34%; n=12).

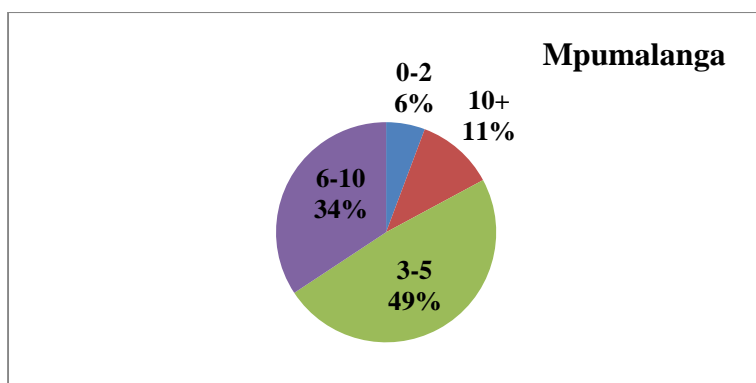


Figure 4-8: Mpumalanga working hours

In summary, the SARCS counsellors are predominantly female with a wide range of age groups, spanning from 25 to 54 in Limpopo and younger than 25 to over 60 in Mpumalanga. The education level of the counsellors is indicative of the changes we see in South Africa: a young work group of professionals with tertiary education and strong opinions. In addition to that, there is the older work group with the years of experience. The figures below, 4-9 and 4-10, clearly indicate the working years at the clinic per age group. There are peaks at 6 – 10 and 10 plus years among the 35 and up age groups in both Limpopo and Mpumalanga as well as a peak at 3 – 5 years for the 25 to 34 group, specifically in Limpopo. In Mpumalanga, it is quite noticeable that there is a strong young work group entering with peaks at 10 plus working years in the 35 – 39 as well as the 50 – 54 groups. This opens up great opportunity for mentoring programmes and the passing on of knowledge. As indicated in Section C, changes are being seen in diseases. What sort of changes? The level of experience held by some in the clinic can assist in answering that question. The knowledge held by the staff can be harnessed and used to create greater awareness among the staff and public.

The hours worked per day as indicated by the participants are not excessive; the counsellors are therefore not over-extended and over-committed which can often lead to apathy and/or frustration.

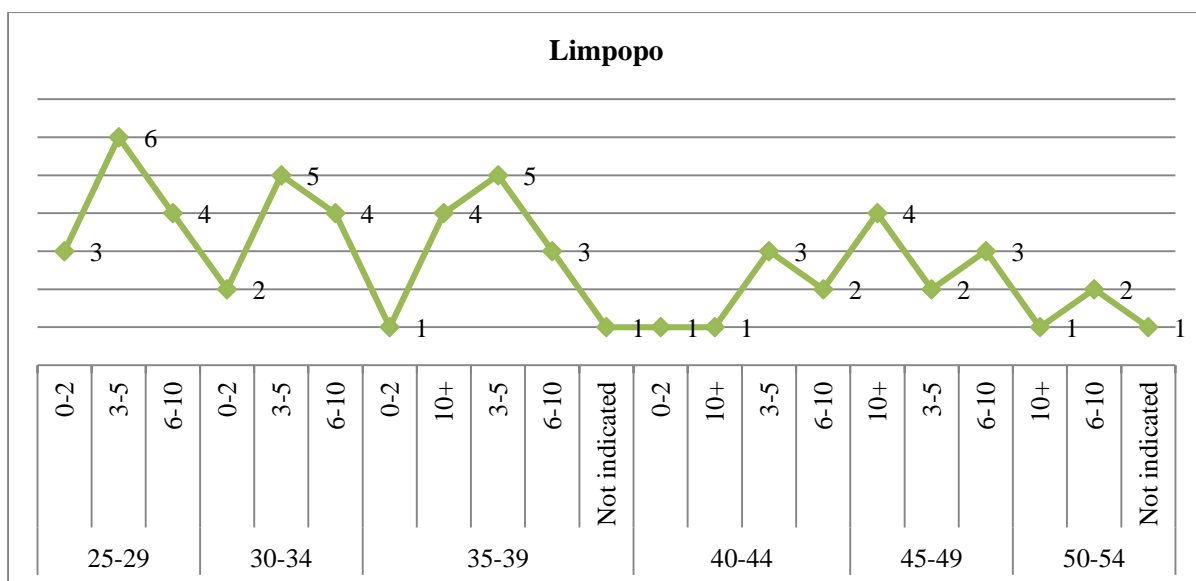


Figure 4-9: Limpopo work experience per age group

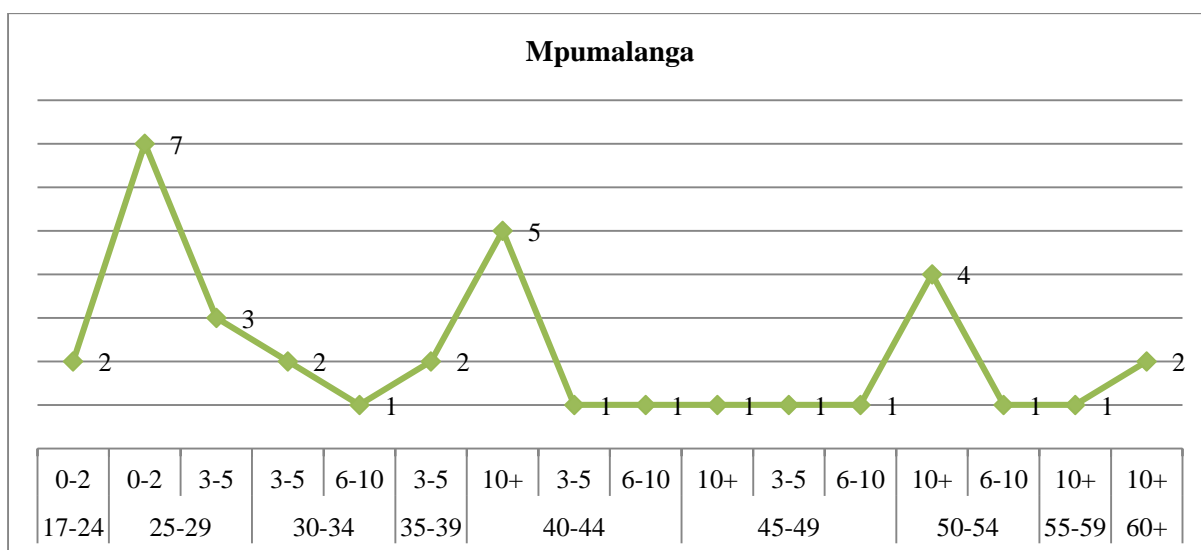


Figure 4-10: Mpumalanga work experience per age group

Opinions

Section A: CLIMATE CHANGE

Section A asked questions around climate and weather in order to establish what the opinion of the participants is regarding these concepts. In both Limpopo and Mpumalanga, the participants agreed that our climate is changing with a strong view, especially in Mpumalanga, that our weather is changing. With the small number of responses, KZN feedback was a clear indication that both climate and weather is changing. This is illustrated in the below figures, 4-11 and 4-12.

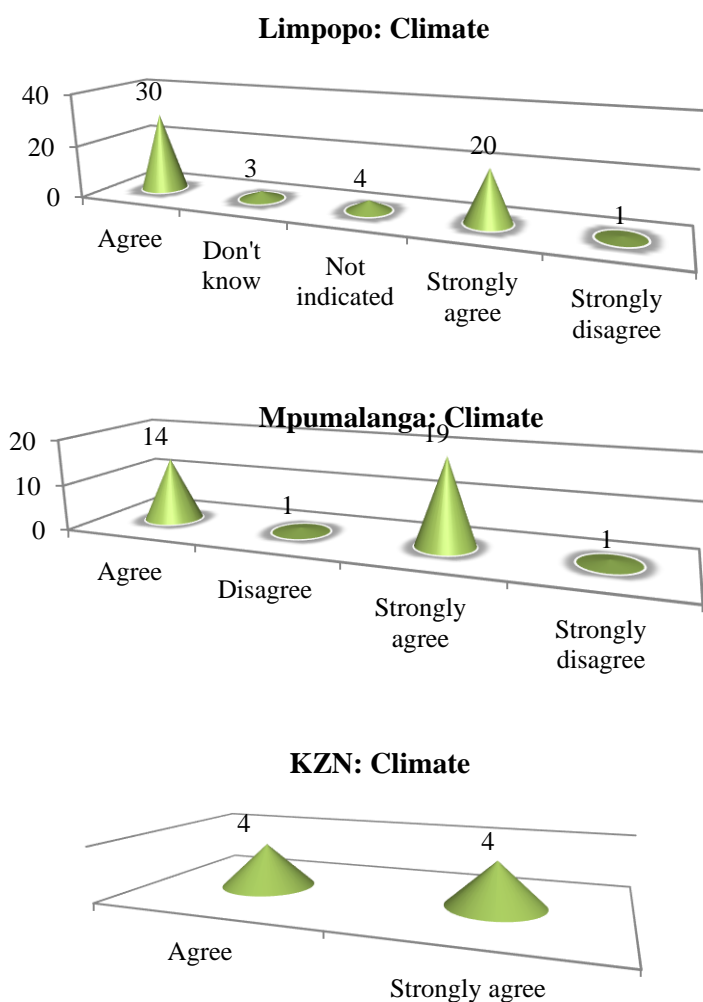


Figure 4-11: Climate is changing

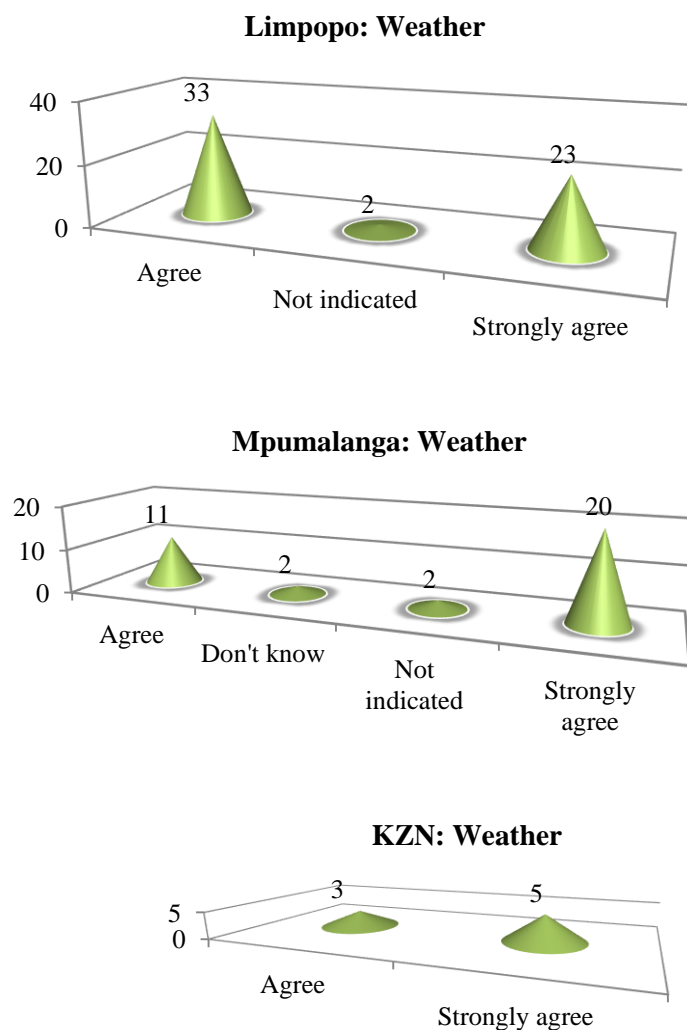


Figure 4-12: Weather is changing

Separating the two concepts the question was whether climate and weather are the same. The responses in Limpopo were in the majority disagreeing with the statement, 50% (n=29) of responses, while 29% (n=17) agreed with the statement. In Mpumalanga, the majority agreed with the statement, 74% (n=26) of responses, while 23% (n=8) disagreed. IN KZN, the responses were spread across the options with a small majority agreeing with the statement.

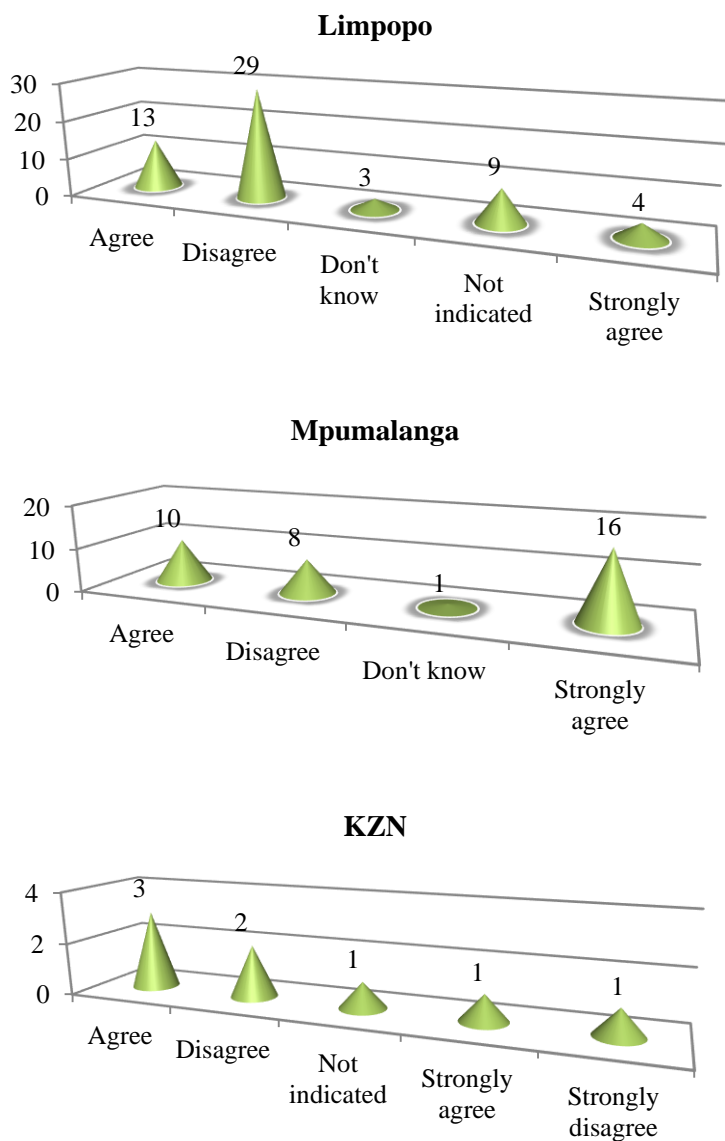


Figure 4-13: Climate and weather

The concept of man-induced global warming presented strong views in Limpopo and Mpumalanga with the majority responses agreeing with the statement. KZN, with the small number of respondents, tended to agree.

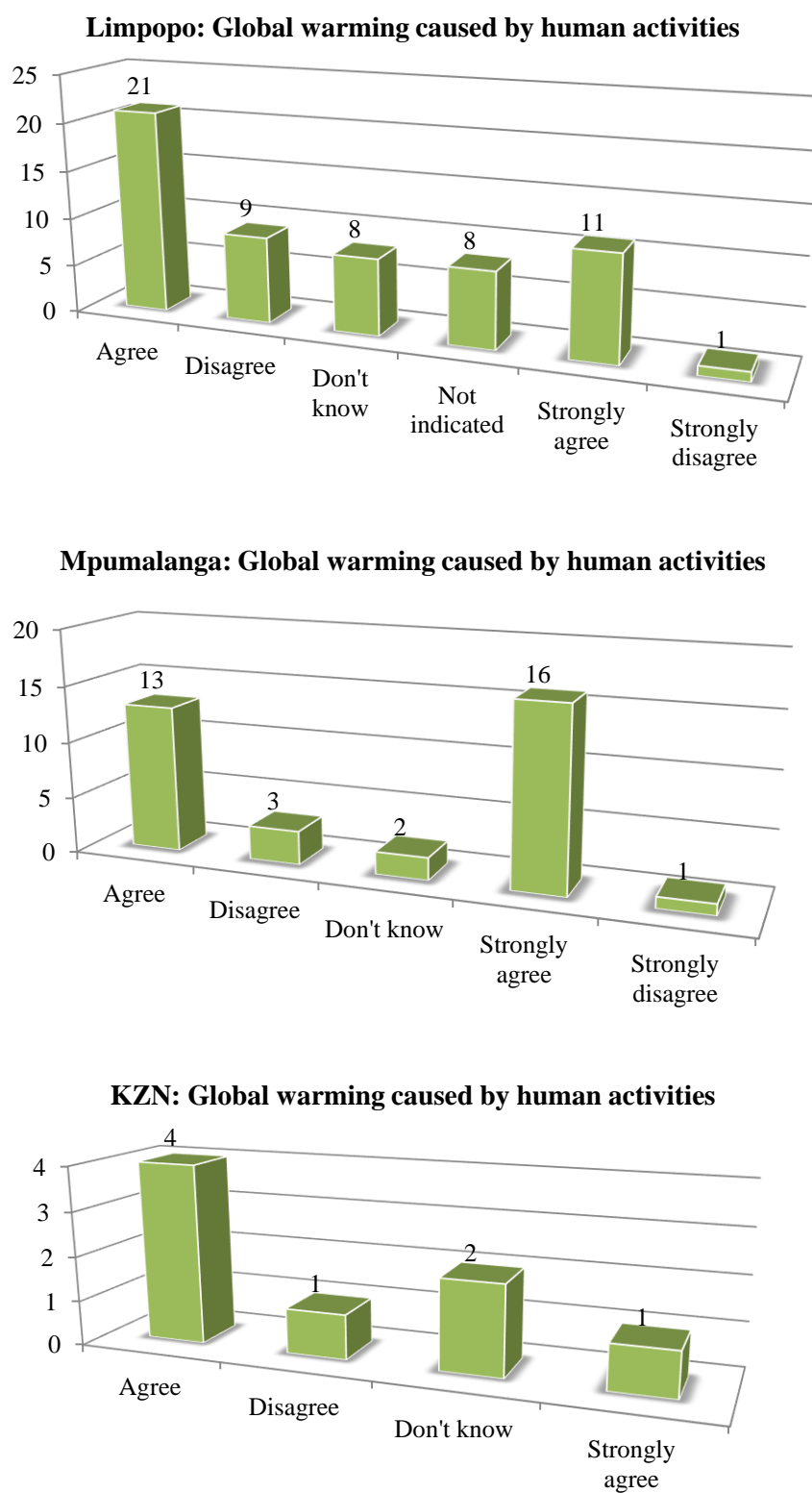


Figure 4-14: Global warming

Consistent with the views on human-induced global warming, participants in all three provinces agreed that man's activities are the cause of increased levels of carbon dioxide in the air.

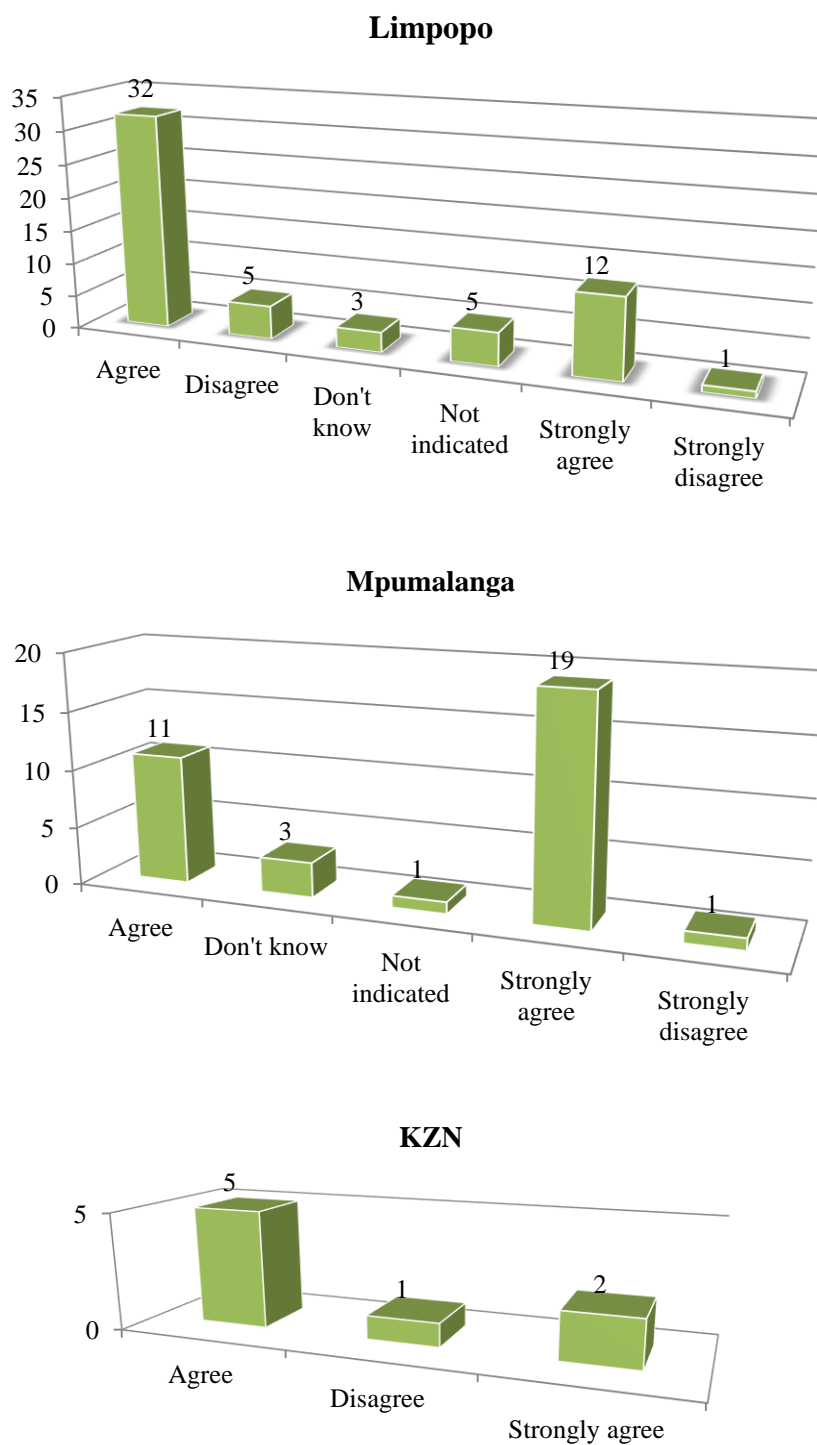


Figure 4-15: Carbon dioxide levels

The opinions of the participants with regards to climate change affecting human health indicates a strong leaning toward agreeing with the statement in Limpopo, Mpumalanga and KZN.

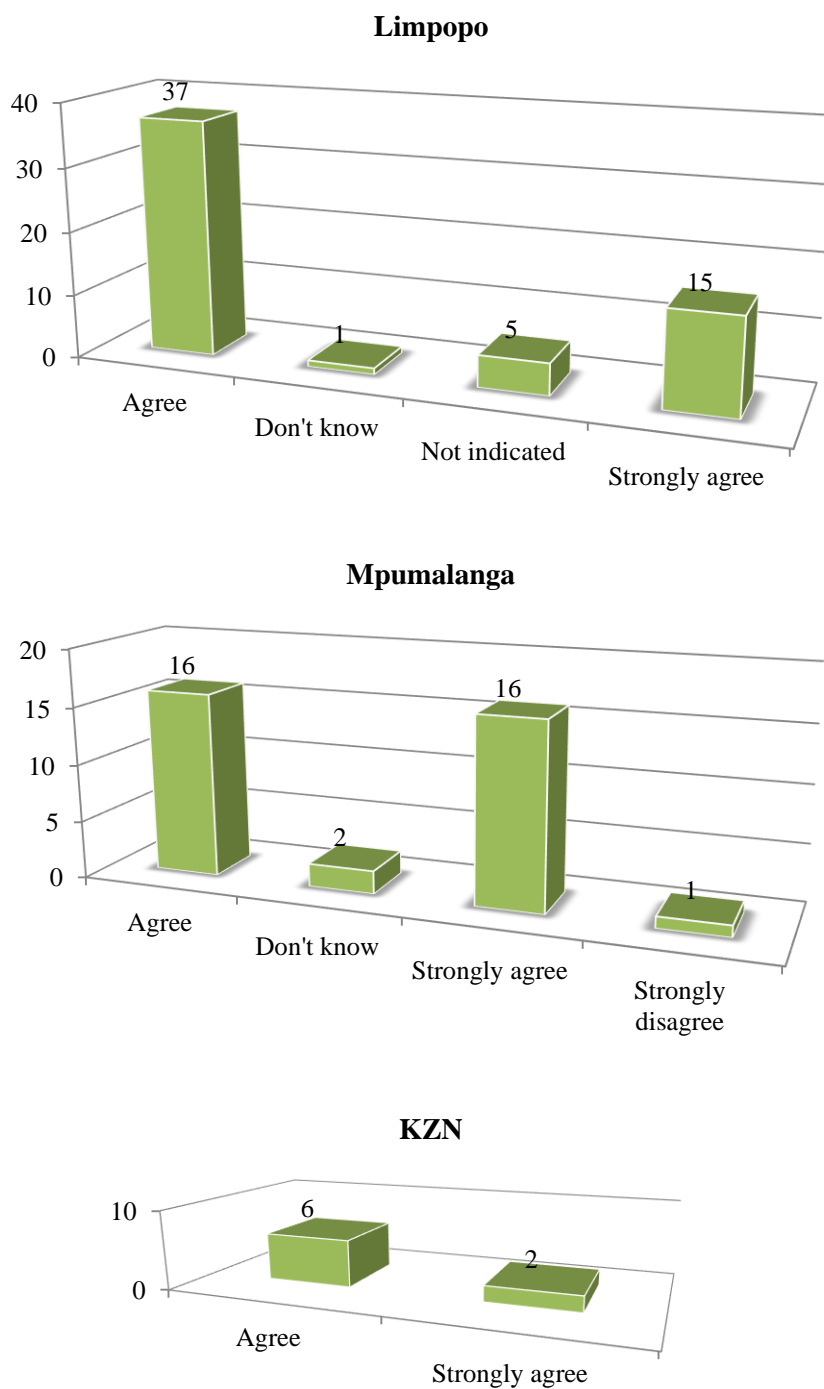


Figure 4-16: Human health

Section B: CLIMATE CHANGE AND HUMAN HEALTH

Section B attempts to link climate change and diseases. There was a challenge with the vernacular and a clear understanding of certain words was lacking.

Limpopo, Mpumalanga and KZN participants tended to agree that diseases are influenced by changes in the weather.

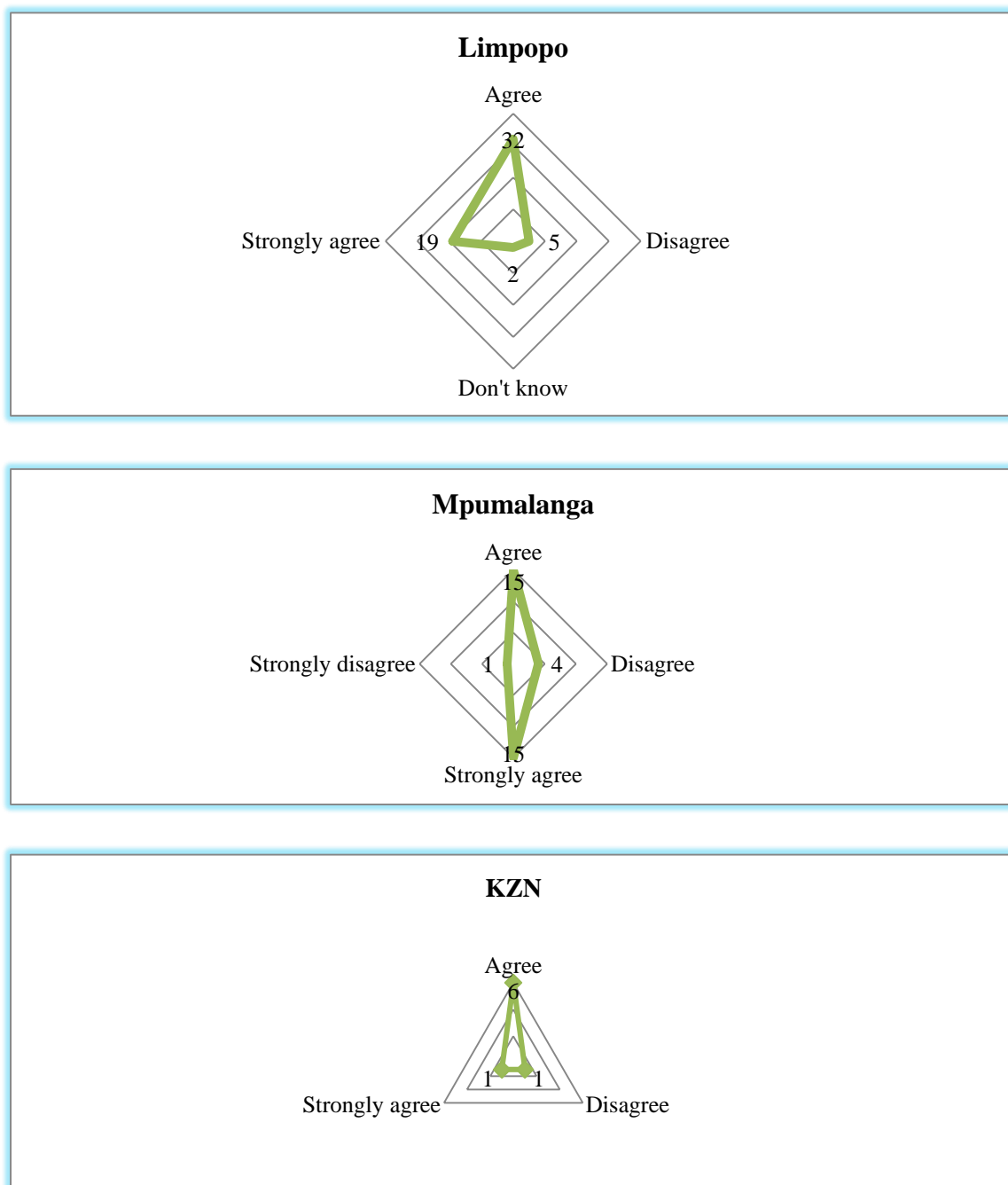


Figure 4-17: Diseases and weather

Limpopo and Mpumalanga participants agreed that diseases carried by insects will be affected by changes in climate. This is significant and displays awareness. KZN, tended to agree with the majority indicating that they did not know.

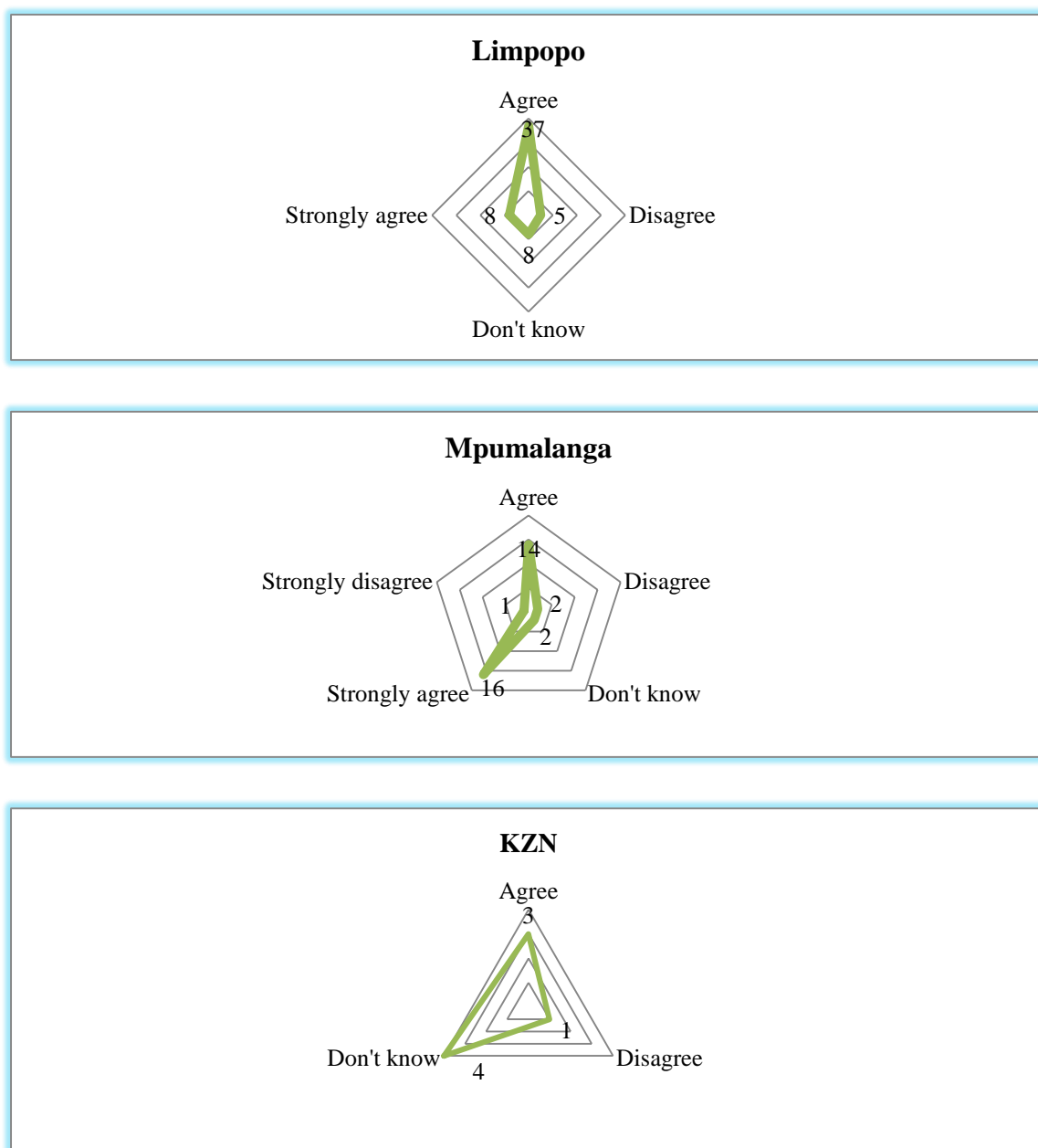


Figure 4-18: Vector-borne diseases

The challenge with the vernacular was identified in the next statement regarding vector-borne diseases. Limpopo participants were split between agreeing and not knowing. Mpumalanga participants seemed clearer with regards to the phrase vector-borne and the majority agreed with the statement. KZN participants were unsure with the majority agreeing with the statement.

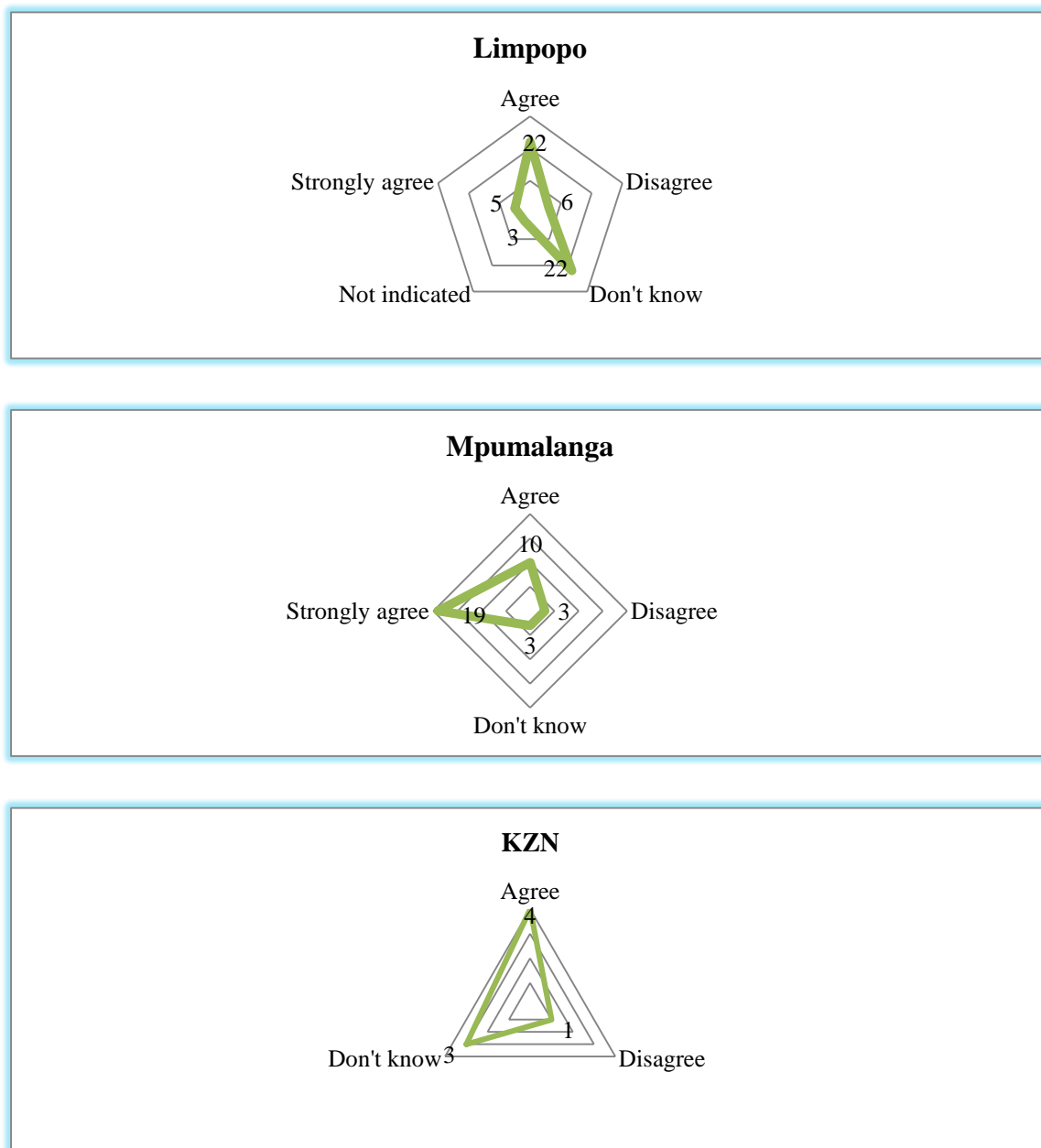


Figure 4-19: Insect-borne diseases

The term water-borne is a more familiar term to the participants and the responses from Limpopo indicated the majority, 65% (n=38), agreed with the statement, while 26% (n=15) indicated that they did not know. Mpumalanga participants indicate agreement with the statement, 80% (n=28). KZN responses were between not knowing and agreeing.

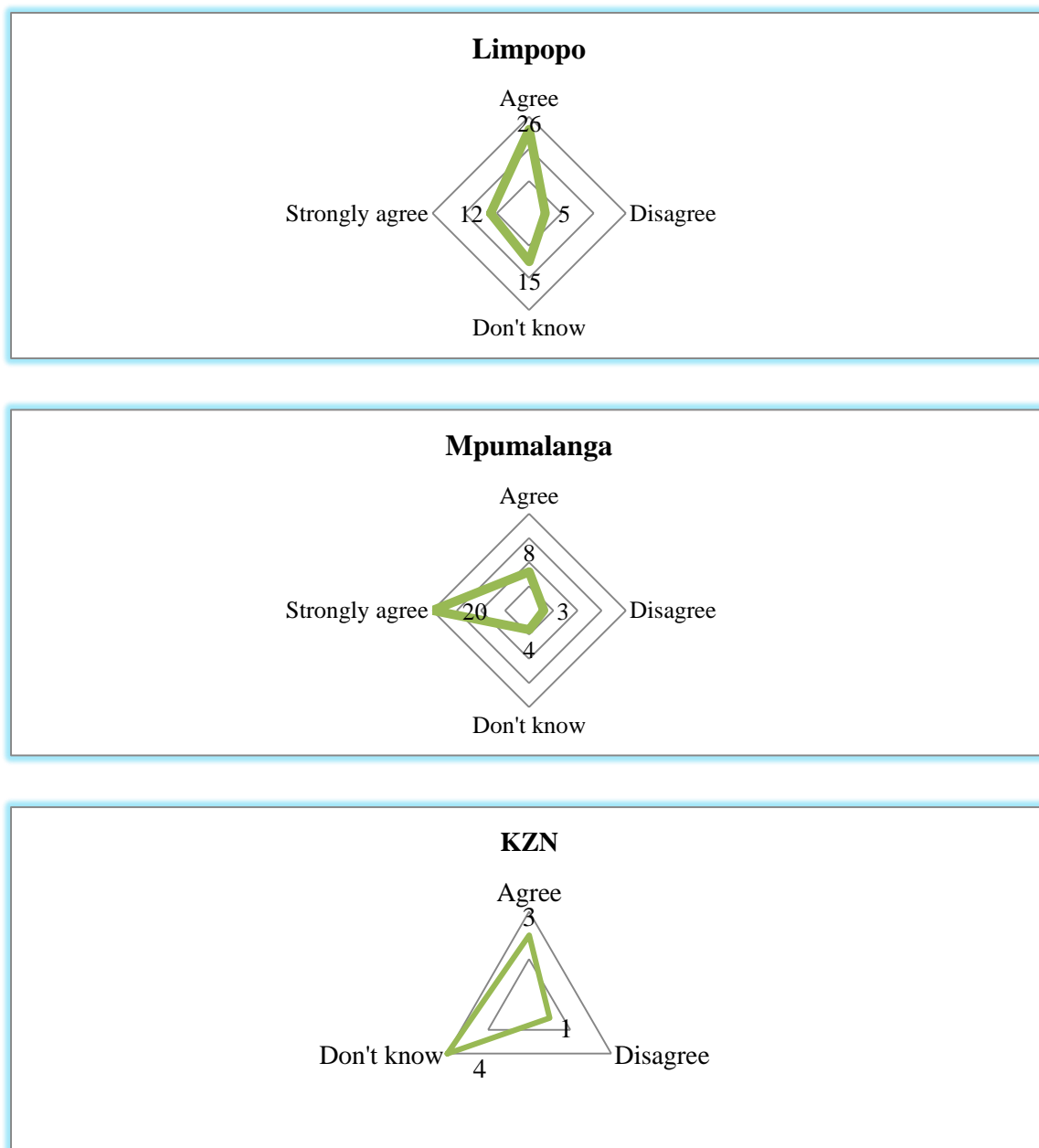


Figure 4-20: Water-borne diseases

Considering if vector-borne and water-borne diseases are infectious would be determined by the understanding of the terms. The responses were mixed between agreeing and not knowing, while Mpumalanga participants were in agreement and KZN not knowing or agreeing.

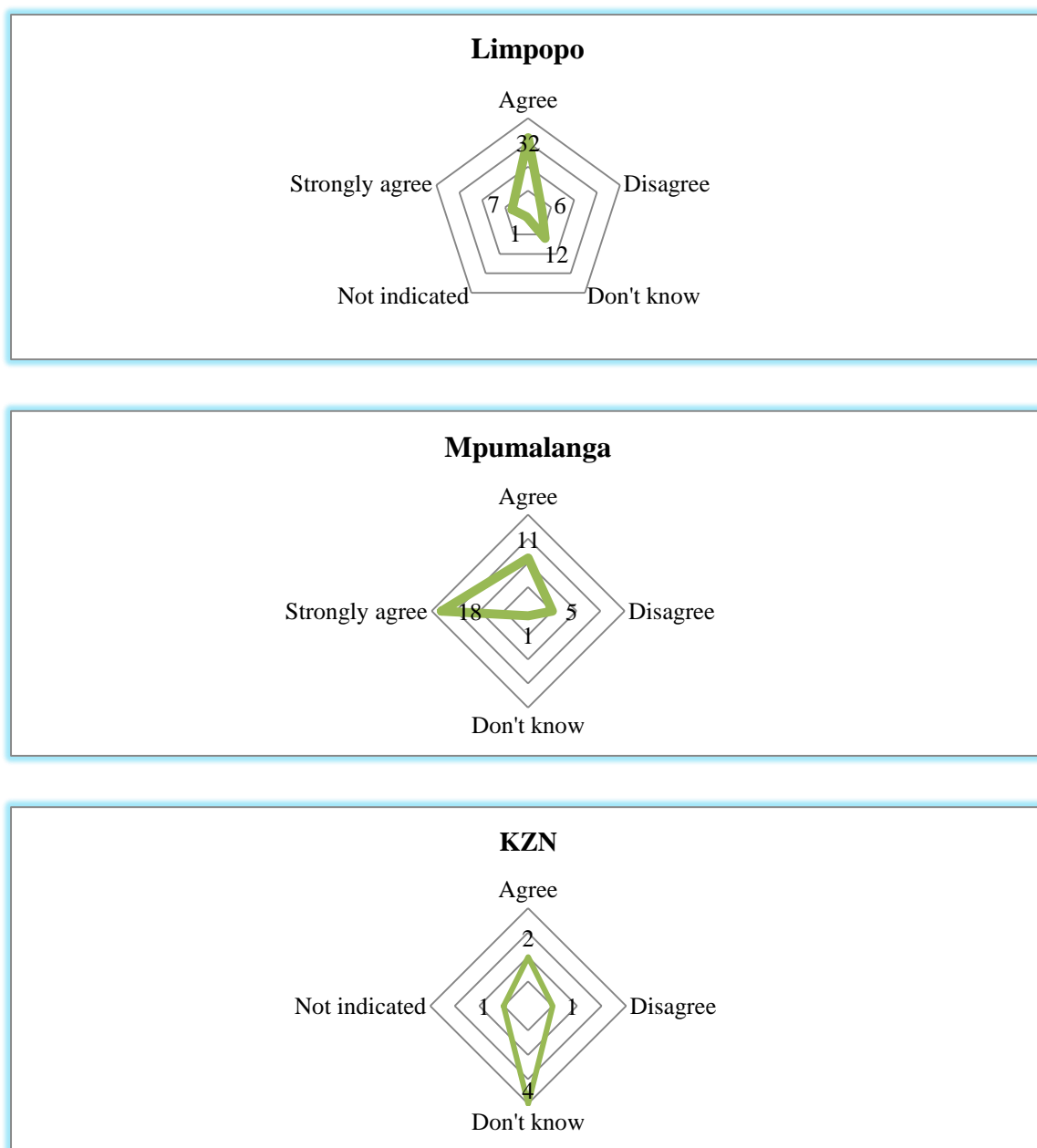


Figure 4-21: Infectious diseases

Participants in both Limpopo and Mpumalanga agree with the statement that infectious diseases can travel with people. This is significant and important in laying a foundation to improve on education and training: be aware, pick up on unfamiliar symptoms and complaints.

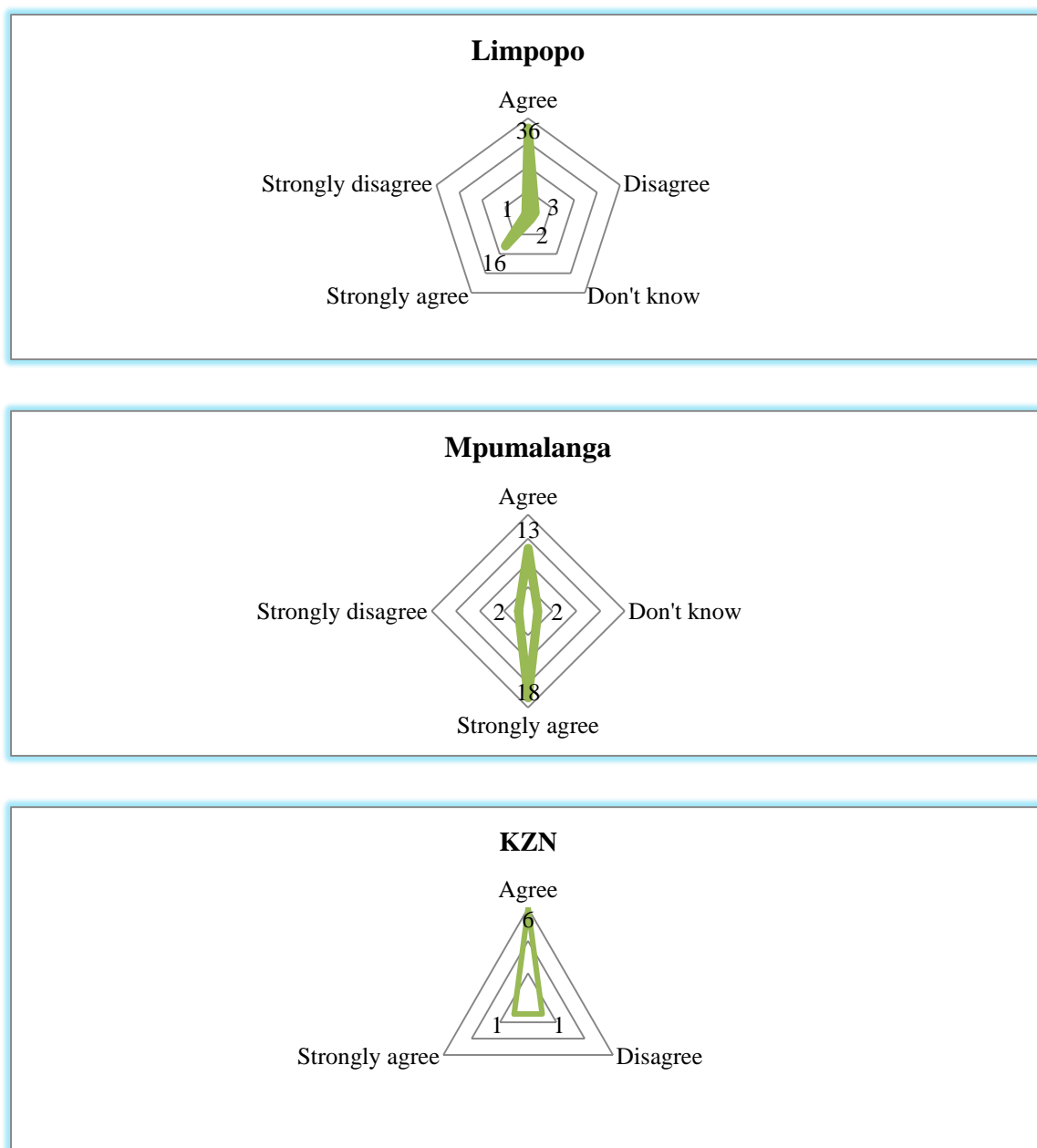


Figure 4-22: Travel

Malaria is an age-old disease afflicting many in Africa. The opinions among the SARCS staff in all three provinces indicate agreement that malaria is a threat to public health. All agree that malaria is a tropical disease.

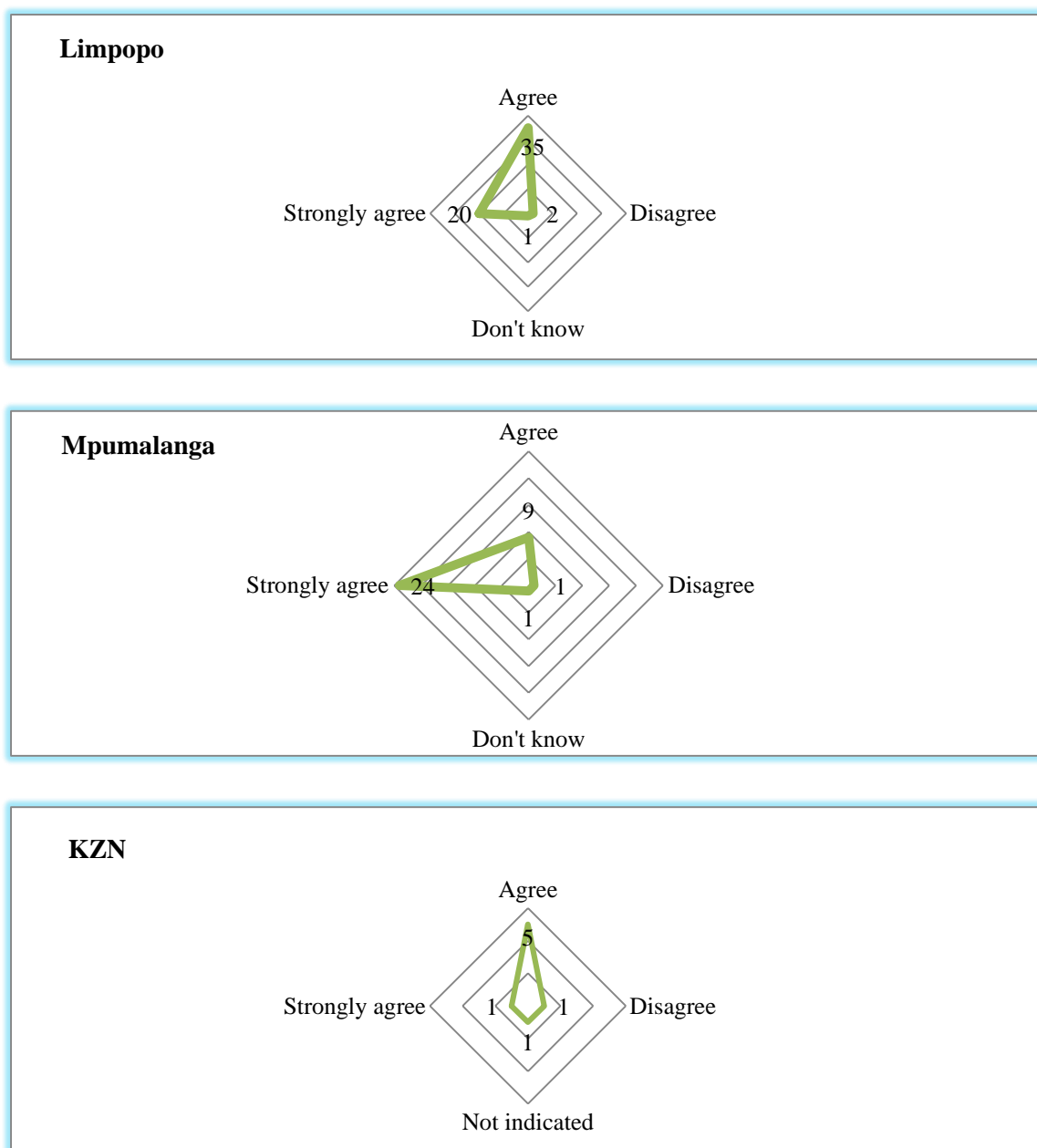


Figure 4-23: Malaria

Overall, there is agreement that diseases are affected by climate and specifically those carried by insects. It is also agreed that diseases can travel with people. The term *awareness* once again comes to mind. Public healthcare workers are in a very important position to be aware of, and detect, the out of place symptoms and conditions.

Section C: PRIMARY HEALTHCARE

Section C directs attention to primary / public healthcare and the opinions and perceptions of the counsellors with regards to resources, monitoring and improvement. The responses are shown below in Figure 4-24 and are split into the age groups. It is noted that the majority of participants agree that there are sufficient resources to assist with the job. This creates a very positive outlook on the facilities at the local clinics. No demographics are available for KZN so the figure only indicates responses.

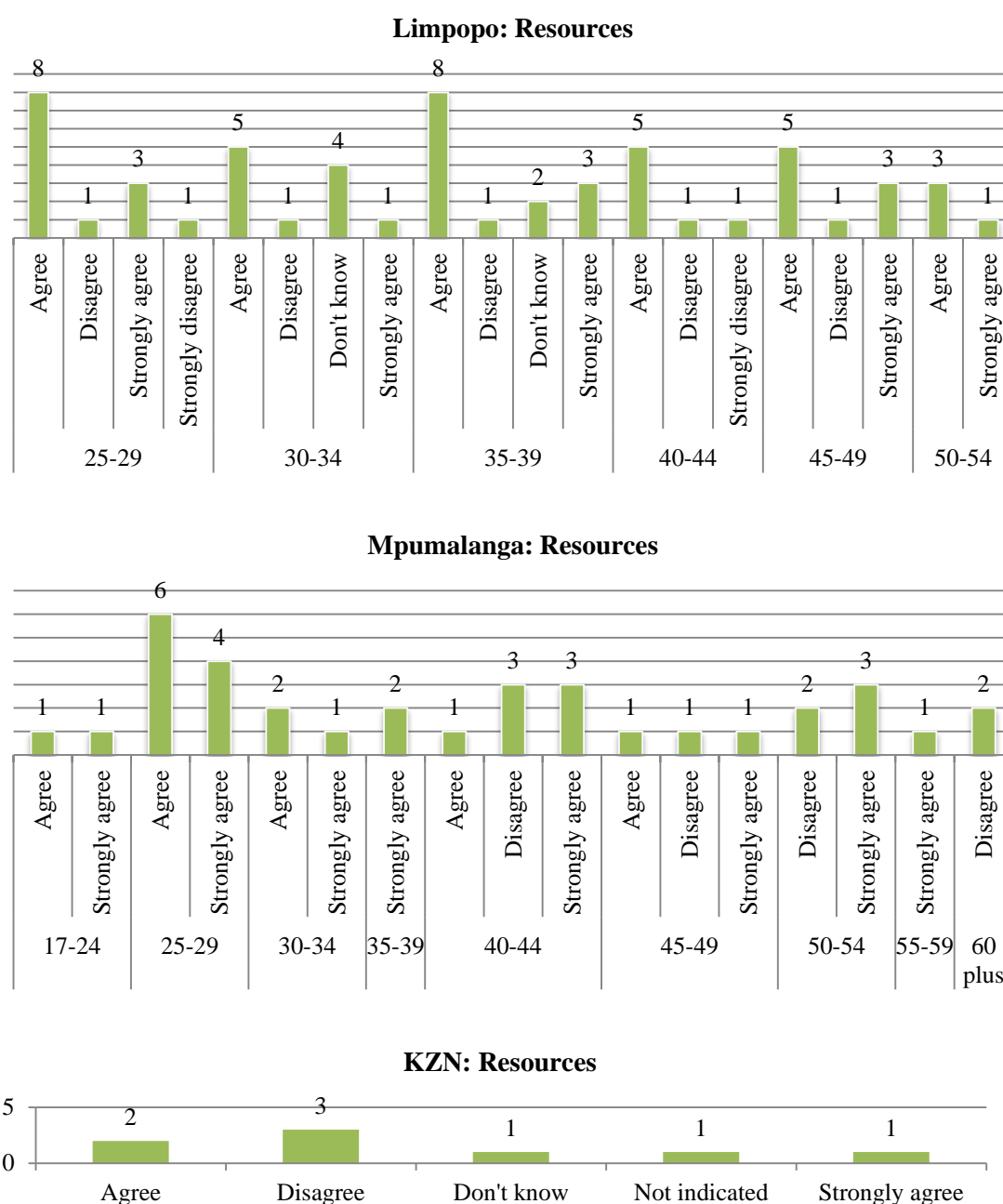


Figure 4-24: Resources

The majority of the participants agree that there are changes in the diseases we see. Limpopo participants either agreed or strongly agreed whereas Mpumalanga participants are not all that certain and some admitted to not knowing while others disagreed. KZN participants were in agreement.

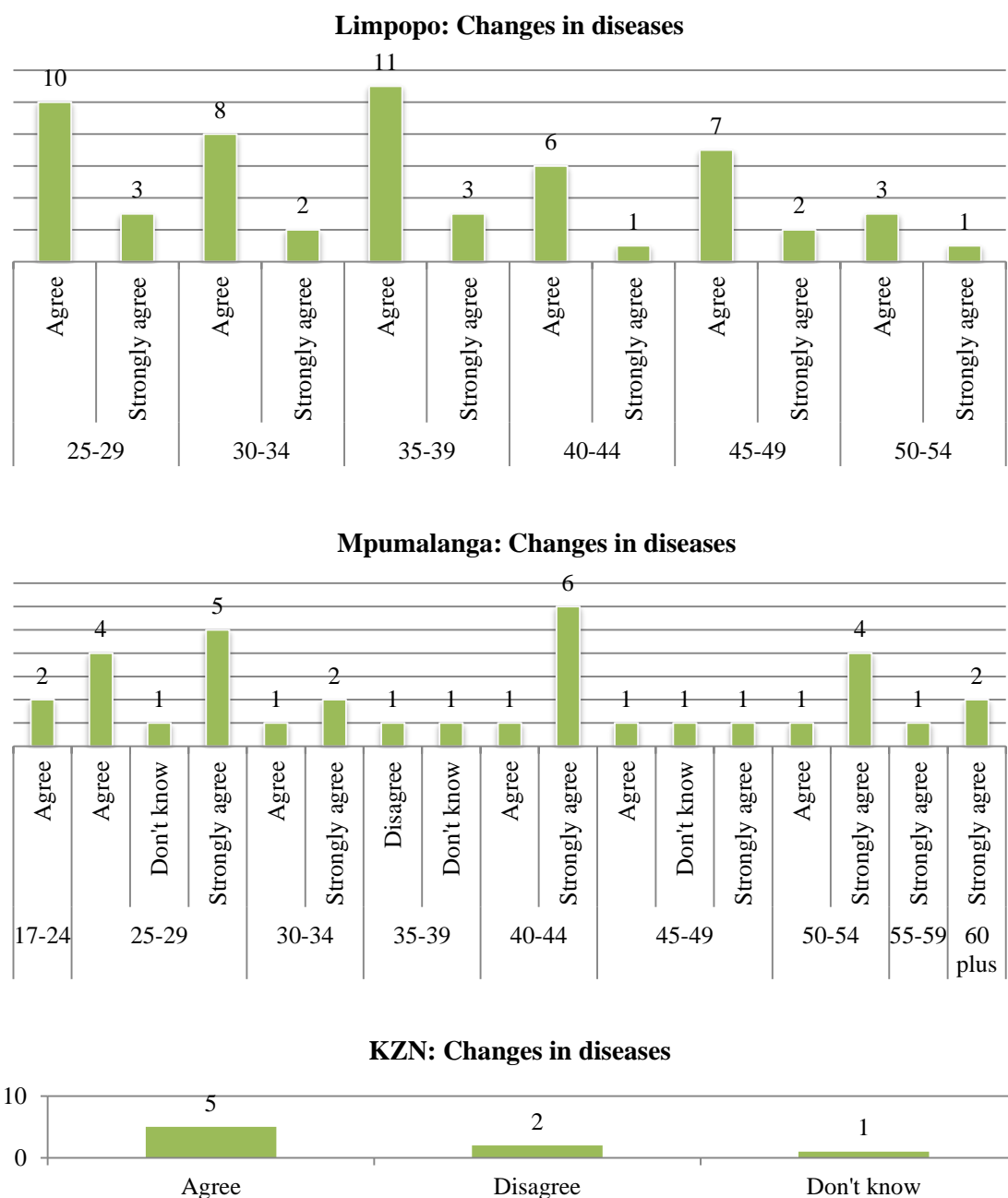


Figure 4-25: Changes in disease

Responding to the statement that there is an organisation monitoring these changes, most participants agree but there are those who indicated that they did not know. The figures below indicate the distribution of responses.

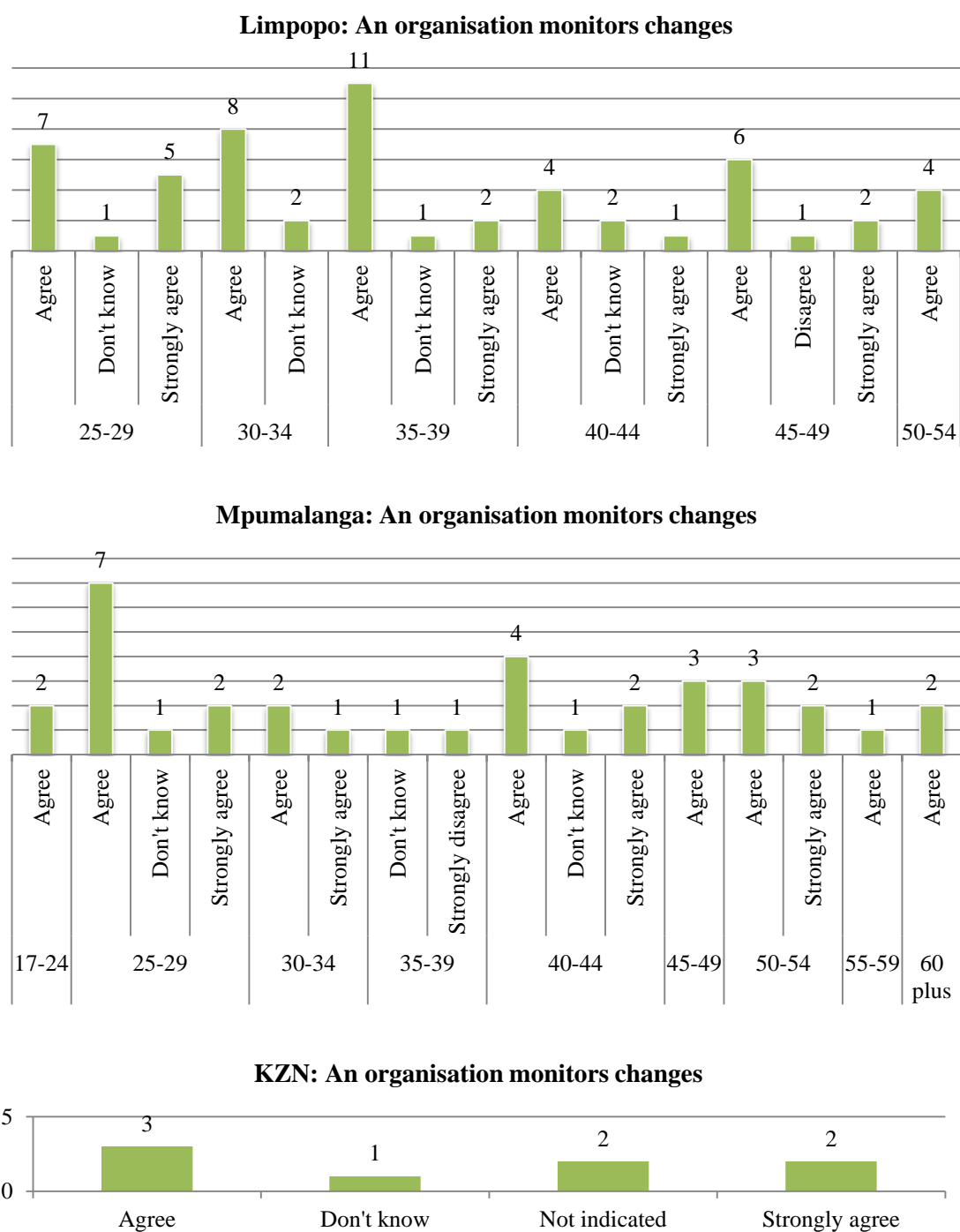


Figure 4-26: Disease monitoring

Is more needed to improve primary healthcare? Both Limpopo and Mpumalanga participants seem to think there is. Limpopo showed very clear opinions while some participants in Mpumalanga differed and disagreed with the statement. KZN participants indicate strong agreement.

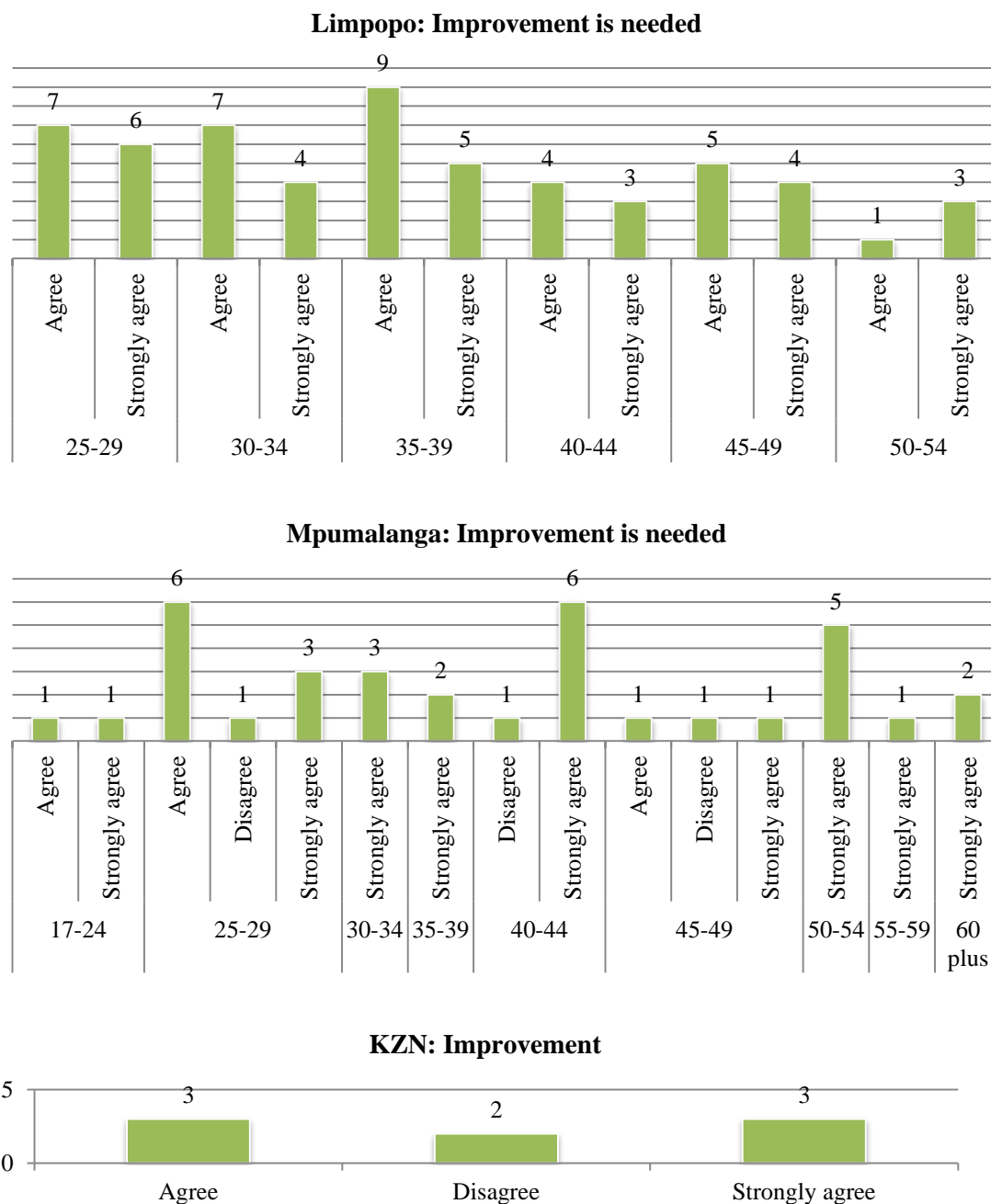


Figure 4-27: Primary healthcare

Section D: GENERAL INFORMATION ABOUT THE CLINIC

The clinics in Limpopo and Mpumalanga are very busy and majority responses indicate that more than 80 patients are seen per day at the clinics.

Limpopo: Patients per day

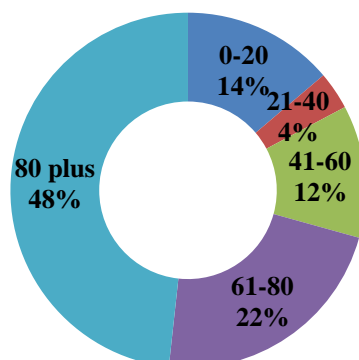


Figure 4-28: Limpopo: Patients per day

The clinics in Limpopo and Mpumalanga see a large number of patients per day. Not all of these patients are seen by the counsellors. There is, however, a lot of interaction between the staff members at the clinics.

Mpumalanga: Patients per day

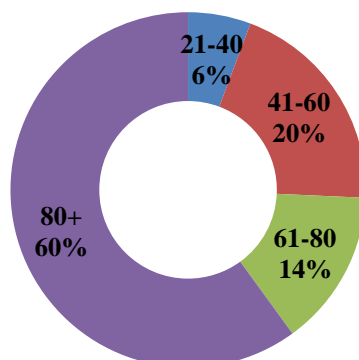


Figure 4-29: Mpumalanga: Patients per day

The majority of the patients seen are female, closely followed by responses indicating that the ratio between male and female is equal.

Limpopo: Patient gender

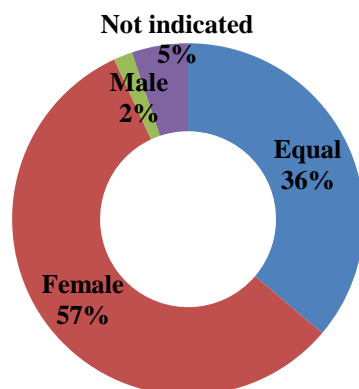


Figure 4-30: Limpopo: Patient gender

Mpumalanga: Patient gender

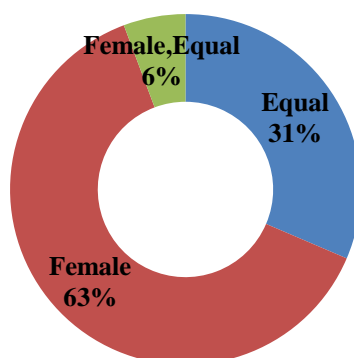


Figure 4-31: Mpumalanga: Patient gender

4.3 Discussion

As seen in Figures 4-3 and 4-4, there is an association between age group and education level. The majority of participants with a post matric qualification are between the ages of 25 – 29. This is indicative of the progress South Africa has experienced over the past 20 years.

Education is emphasised in households and young people leaving school are encouraged to study, get a qualification and start working. These young professionals will become the new leaders of tomorrow. It is, therefore, important to pay attention to their opinions. The percentage of workers between the ages of 25 and 29 is rising and, in Mpumalanga specifically, this group represents the majority age group.

There is an association between age group and opinion. Age is a significant variable since there is more awareness and discussion regarding the climate change in schools and tertiary institutions. Age and education level, in this study, is positively related to awareness. The percentage of *Don't know* responses in Section A of the questionnaire relating to Climate Change reveals the following:

Limpopo	Age Group	Total Variables	Don't Know responses	Percentage
	25-29	130	16	12
	30-34	110	17	15
	35-39	140	11	8
	40-44	70	14	20
	45-49	90	15	17
	50-54	40	6	15

The lowest number of Don't know responses in Limpopo for this section fall predominantly within the younger age groups.

The number of participants in Mpumalanga, 35, with the majority being between the ages of 25 – 29 indicate lower Don't know responses between the age groups 30 – 44. However, the number of participants is significantly lower.

Mpumalanga	Age Group	Total Variables	Don't Know responses	Percentage
	25-29	100	11	11
	30-34	30	2	6
	35-39	20	1	5
	40-44	70	6	8
	45-49	30	4	13
	50-54	50	0	0

Responses regarding changes in climate and weather are predominantly positive. Separating the concepts of climate and weather saw a lot of uncertainty came through. The results received do indicate that the age groups of 25 – 29 and 30 – 34 acknowledge that the concepts of climate and weather differ.

The majority of responses indicate agreement that mankind's activities are the cause of global warming and increased levels of carbon dioxide. Once again, the results show an association between age group and opinion in that the majority of these responses fall within the age group of 25 – 29 and 30 – 34.

Participants agreed in the majority that climate change can affect human health. Whether a connection is made in the mind of the participant that mankind's activities are the cause of climate change and climate change can affect mankind's health, therefore mankind's activities affect mankind's health is uncertain. Regardless, this can be harnessed and form part of the education programmes in healthcare. It is about creating and ensuring awareness; it about prevention; it is about change.

Section B relating to Climate Change and Human Health, with questions regarding infectious diseases indicates that the majority agree that infectious diseases are influenced by changes in

climate. So what of it? Awareness must be made of the significance a very hot day, for example, can have on public health. An interview was held with a professional nurse in Mokopane and her greatest concern was not for infectious diseases, but more so for the non-communicable diseases afflicting the local residents. The so-called lifestyle diseases are affecting communities significantly, such as hypertension, diabetes, cardiovascular concerns and hyperlipidaemia. Extreme weather conditions and the effect on infectious disease patterns could significantly compromise an already strained healthcare system.

Section C focuses specifically on public healthcare services. Strong opinions indicate that changes are being seen in diseases, resources are sufficient, patients are referred when required but more must be done to improve healthcare. A well-known radio talk show presenter and commentator indicated in the interview that the more robust primary health care the less pressure on secondary and tertiary healthcare institutions.

In response to the question regarding government spending on healthcare the interviewees were specific and mentioned primary healthcare, clean sewage and education.

Two important factors come out: education and funding. Addressing these factors will significantly improve healthcare provision in light of climate changes we are experiencing and will continue to experience and the burden of disease.

Man is considered the guardian of all that exists, and is most responsible for taking care of his own. It is strange that we have moved away from that basic concept and find ourselves so far removed from it – damaging the Earth, expending its resources, damaging ourselves and damaging others.

The results obtained from the discussion clearly indicate that people have an opinion and can positively affect change using that opinion. Gaining knowledge with regards to the world and the changes that are taking place in the world will enhance that opinion. The goal is not to change people's opinions but rather to change the way they think and form those opinions.

The hypothesis mentioned in 1.6 referred to determining if training was required or not. The younger generation are thirsting for knowledge and are supported by their parents to study and learn. The following hypothesis is therefore true for this study:

H1: Training should be provided to healthcare workers as there is insufficient knowledge among such staff regarding changing disease patterns resulting from the effects of climate change.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The scientific community agrees that climate variability and change is a reality with changes likely to increase in the future. As a growing population, pressures exist on current infrastructure to support the needs of the population, specifically with regards to public healthcare. The South African government is looking to improve infrastructure and services. However, the Department of Health is making use of the services of the South African Red Cross Society in local clinics, specifically as HIV/AIDS counsellors.

Education level of these counsellors is seen to be increasing from matric to post-matric qualifications. This indicates a great awareness amongst the population that education is the key to unlocking improvements and alleviating very and human suffering.

It can be predicted that climate change or variability will affect disease patterns and bring these closer to naïve areas challenging healthcare facilities and staff. If this occurs, will the threat of infectious disease be met with apathy or awareness?

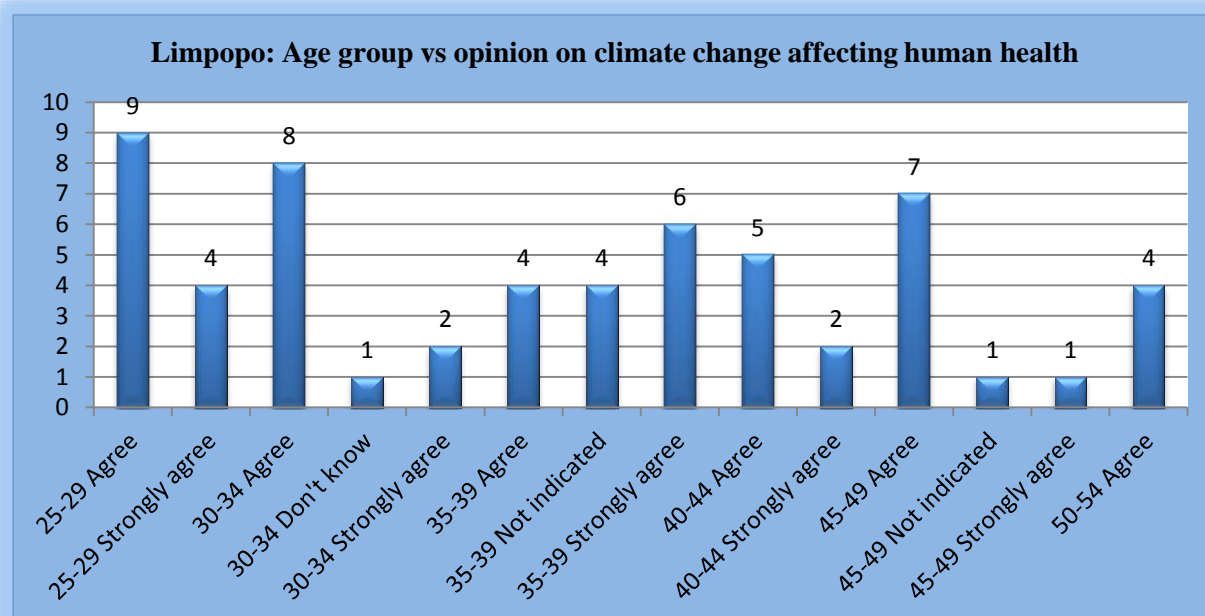


Figure 5-1: Limpopo: Age group opinion

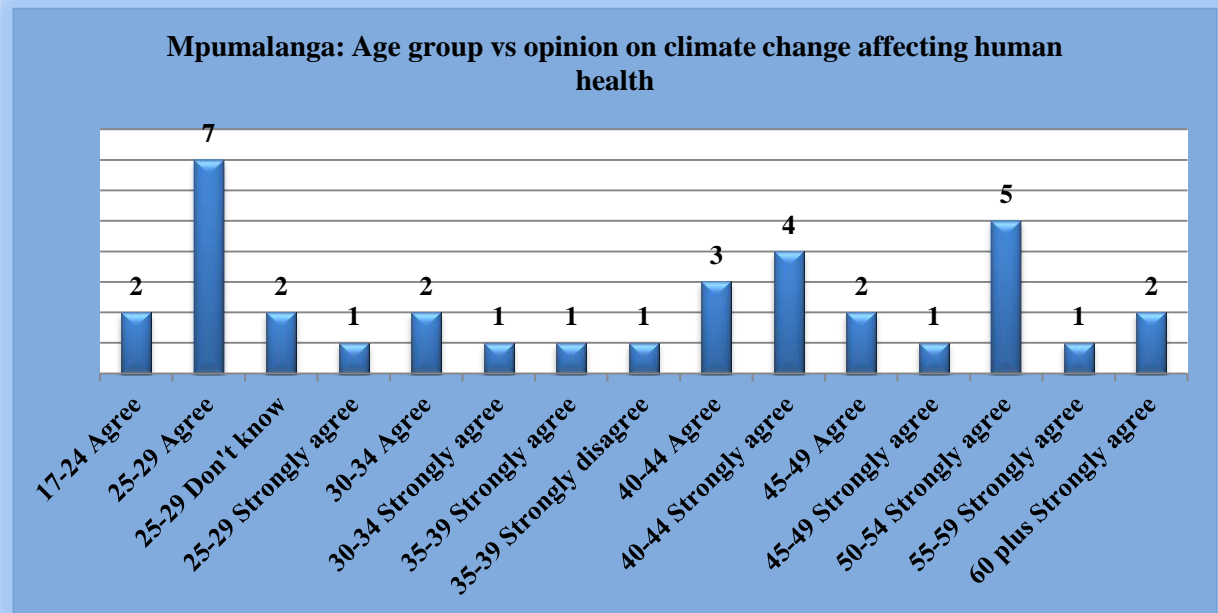


Figure 5-2: Mpumalanga: Age group opinion

5.2 Limitations of the study

Questionnaire:

1. The language of the questionnaire is English and this is not the first language of the participants. Some of the words were not fully understood and rendered the responses unfit for use;
2. There were insufficient responses (101) and may have required 300 to 1000 in order to be significant;
3. There were too many options to some of the questions, for example question 5 of Section D regarding the climate of the area. In addition, the need for a response is questionable;
4. Too many unnecessary categories with multiple answers given by participants, resulting in the stripping out of the question from the analysis;
5. No quantitative results were obtained and presented;

6. The terms unfamiliar to the participants could very well have been because of the vernacular – a biological term with no vernacular equivalent for point of reference or interpretation;
7. Race was not asked as part of the demographic data as it was not deemed necessary. From a statistical response perspective, it may influence the response – especially if culturally or religiously defined. These were not catered for in the questionnaire. The responses were expected to be based on current affairs issues and what has been discussed in the media;

The research study including the questionnaires was submitted to the CAES Research Ethics Committee at Unisa and approved as reference 2013/CAES/059 as indicated in Appendix F.

5.3 Recommendations

Recommendations arise from this study and these recommendations can be made by the individual provinces departments of health, as well as other key stakeholders who are interested in climate change issues and healthcare. The recommendations are based on information given to South African Red Cross Society, how the information is disseminated and the awareness created:

1. Education

The National Environmental Education Foundation (NEEF) was configured by the United States congress in 1990 to *advance environmental knowledge*. It was established as a complementary organisation to the Environmental Protection Agency (EPA). The NEEF makes use of a powerful network of professionals and other leaders to reach the public, assisting them to make informed choices for a healthy life and environment. They have a powerful network of professionals, government agencies, businesses and non-profit organisations. They support the movement to inform the public on the potential impact of climate change on human health. The following recommendations are made by them with regards to *How Health Professionals Can Protect Public Health*:

- Diagnose and monitor health effects as a result of climate change;

- Be credible experts and educate patients, their families and community members about the increased disease risks from climate change while providing understanding and support;
- Speak out for public policy to include public health measures at both a local and national level;
- Be leaders and guide community members to adapt to climate change in both private and public health sectors;
- Promote healthier lifestyles and reduce greenhouse gas emissions – specifically with regards to transportation.

The recommendations adopted by the NEEF are exactly the recommendations promoted in this study.

The Australian Healthcare and Hospital Association's Deeble Institute (2014) issued a brief entitled: **Impacts of climate change on public health in Australia: Recommendations for new policies and practices for adaptation within the public health sector**. The paper acknowledges that policymakers are faced with challenges regarding funding and an ageing society but points to climate change impacts generating high costs if current healthcare strategies are inadequate. They recommend coherent policies and funding. In addition, research organisations and health institutions must collaborate to develop and conduct cost-effective, long-term studies on the impacts of climate change. Cost saving of acting now must be presented to government and other sectors that impact societies infrastructure: water, housing, transport, etc. A comprehensive surveillance system (similar to an early warning system) in order to monitor the relationship between environmental, societal and health factors must be implemented. Assessments and indicators in the health sector must be in place in order to develop planned, evidence-based adaptations with the goal of engendering greater resilience. They emphasise that the health sector must communicate climate change as a human health issue rather than an environmental problem (Walters, *et al*, 2014).

The issue of climate change affecting human health is acknowledged by developed countries. Two opinions have been used above. It is apparent that the role of educated healthcare workers in assisting communities adapt and increase resilience is pivotal. The South African Government acknowledges the link between climate change and human health; however, this has not filtered into the healthcare system. We are often

faced with well-presented ideas and policy suggestions. The realisation of these is often lacking. For example, the DEA NCCR Green paper and White Paper documented a lot of what will be done, but little can be seen of what has been done. Could it be that the information has not filtered down to the public? The public has not been enlightened as to what potentially awaits our well-being due to climate change. It is government's role to ensure the public are protected and sufficient education is provided in terms that all can understand. Key role players exist in public healthcare and education should start with them. As mentioned in the papers, mass media is a powerful way of getting information across to the public – this should be utilised and not just spoken about.

2. Funding

According to the brief issued by the Deeble Institute, endorsed by the Australian Healthcare and Hospital Association, no funding has been allocated by the National Health or Medical Research Council to climate related projects. Funding directed at healthcare and education sectors must make provision for climate change related education modules for healthcare workers. In addition, funding must be made available for research into the impact of climate change on public health in South Africa, together with the awareness of healthcare workers and the public.

3. Government policies

Government policies must support education and research programmes, ensuring that healthcare workers are given the relevant information about the impacts of climate change on public health in order to engender awareness and sharing of information. The policies must ensure that the healthcare workers are equipped with the required skills to question patients and determine climate-related concerns, feeding this information forward to the national department.

Government policies must ensure funding is directed in a manner that supports the constitutional right to access to health care services. Extending this further, the right to access is not enough; it should be the right to access to adequate health care services, where adequate includes education and not just treatment. The NCCR Green Paper and White Paper document the policies that the South African government will commit to. The policies retain mitigation and adaptation categories but will reflect on a strategic approach known as “climate change resilient development”. The time-lines used will

be as documented in the White Paper with publication dates being 2010 for the Green Paper in which the policies are documented and 2011 for the White Paper:

- Short-term: five years from date of publication of the policy;
- Medium-term: twenty years from date of publication of the policy;
- Long-term: planning that extends to 2050.

(DEA: 2010, 2011).

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APPENDICES

APPENDIX A: RAW DATA

Table A-1: Distribution of participant age groups and gender per province

Limpopo

Age group	Female	Percentage	Male	Percentage
25-29	11	19	2	3
30-34	10	17	1	2
35-39	12	21	2	3
40-44	7	12	0	0
45-49	9	16	0	0
50-54	4	7	0	0
Total	53	92	5	8

Mpumalanga

Age group	Female	Percentage	Male	Percentage
17-24	0	0	2	6
25-29	8	23	2	6
30-34	3	9	0	0
35-39	0	0	2	6
40-44	3	9	3	9
45-49	3	9	0	0
50-54	5	14	0	0
55-59	1	3	0	0

60+	2	6	0	0
Total	25	73	9	27
One participant of age group 40-44 did not indicate gender				

Table A-2: Distribution of participant education level per province

Education level	Number of participants	Percentage
Limpopo		
No formal schooling	1	2
Pre-primary schooling	1	2
Primary schooling	1	2
Secondary schooling	26	45
Post-matric schooling	27	46
Not indicated	2	3
Total	58	100
Mpumalanga		
No formal schooling	0	0
Pre-primary schooling	1	3
Primary schooling	2	6
Secondary schooling	14	40
Post-matric schooling	17	48
Not indicated	1	3
Total	35	100

Table A-3: Distribution of participant working years

Years	Number of participants	Percentage
Limpopo		
0-2	7	12
3-5	21	36
6-10	18	31
10+	10	17
Not indicated	2	3
Total	58	100
Mpumalanga		
0-2	9	26
3-5	9	26
6-10	4	11
10+	13	37
Total	35	100

Table A-4: Distribution according to working hours per day in Limpopo

Hours per day	Number of participants
10+	3
3-5	2
6-10	53

Total	58
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Table A-5: Distribution according to working hours per day in Mpumalanga

Hours per day	Number of participants
0-2	2
10+	4
3-5	17
6-10	12
Total	35

Table A-6: Number of patients seen per day at the clinic in Limpopo

Patient numbers	Number of participants
0-20	8
21-40	2
41-60	7
61-80	13
80 plus	28
Total	58

Table A-7: Number of patients seen per day at the clinic in Mpumalanga

Patient numbers	Number of participants
21-40	2
41-60	7

61-80	5
80+	21
Total	35

Table A-8: Distribution of patient gender in Limpopo

Patient gender	Number of participants
Equal	21
Female	33
Male	1
Not indicated	3
Total	58

Table A-9: Distribution of patient gender in Mpumalanga

Patient gender	Number of participants
Equal	11
Female	22
Female,Equal	2
Total	35

APPENDIX B:	CONSENT LETTER FROM SARCS
APPENDIX C:	PARTICIPANT / RESPONDENT DEMOGRAPHIC DATA
APPENDIX D:	QUESTIONNAIRE INTRODUCTION AND INSTRUCTIONS
APPENDIX E:	QUESTIONNAIRE
APPENDIX F:	ETHICS REFERENCE LETTER



"Always Needed, Always There"

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Email mokopaneredcross@gmail.com
Web www.redcross.org.za

9th October 2013

To : Shelley Cook

Subject : Confirmation to assist with research study

The above matter bears reference,

The South African Red Cross Society is an international humanitarian organization established to provide services directed to human needs, prevent and alleviate human suffering without any discrimination of gender, creed, age, race and any type of socioeconomic class. The Red Cross Programs are directed and guided by seven fundamental principles of the Red Cross Movement internationally. These principles are a corner stone for our existence. They are: Humanity, Impartiality, Neutrality, Independence, Voluntary Service and Unity. All Red Cross programs are implemented guided by the 7 seven, fundamental principles.

We acknowledge receipt of your request and we are willing to assist you with your research requirements within our ability and resources.

Yours in Humanity

George Mamabolo

Provincial Manager
South African Red Cross Society - Limpopo
Tel : (+27) 15 491 3916
Fax : (+27) 86 679 6654



APPENDIX C: PARTICIPANT / RESPONDENT DEMOGRAPHIC DATA

DEMOGRAPHIC DATA COLLECTION FORM

Basic Demographic information

1. Today's date:

Y	Y	Y	Y	M	M	D	D
---	---	---	---	---	---	---	---

2. Interviewer to record the gender of the participant:

MALE	1	FEMALE	2
------	---	--------	---

3. In which age group are you?

17 - 24		1
25 - 29		2
30- 34		3
35 - 39		4
40 - 44		5
45 - 49		6
50 - 54		7
55 - 59		8
60 and older		9

4. What is your highest formal education level obtained?

No formal schooling		1
Grade 1 - 3		2
Grade 3 - 7		3
Grade 8 - 12		4
Grade 12 plus - specify		5

5. In which province is the clinic located? _____

6. In which town is the clinic located? _____

7. Which is the nearest city located to the clinic? _____

8. For how many years have you been working at the clinic?

0 - 2		1
3 - 5		2
6 - 10		3
More than 10		4

9. On average, how many hours do you work a day?

0 - 2		1
3 - 5		2
6 - 10		3
More than 10		4

APPENDIX D: QUESTIONNAIRE INTRODUCTION AND INSTRUCTIONS

INTRODUCTION AND INSTRUCTIONS FOR COMPLETION OF QUESTIONNAIRE

Introduction

Thank you for taking the time to complete this questionnaire and for agreeing to participate in this study. The questionnaire forms part of a master degree research study for the University of South Africa (UNISA). Kindly note that all information obtained through this questionnaire will be used for the purpose of data collection and study strictly guarding the confidentiality of the participants and respondents.

Collection and collation of data is to survey local awareness of climate change and infectious disease patterns amongst primary healthcare workers together with the opinions of subject matter experts in order to determine the preparedness of public health institutions in combating infectious disease appearance and/or outbreaks - identifying what kind of primary health care is required. The data will be compiled in a report and is the intellectual property of the University of South Africa.

All participants and respondents will remain anonymous.

The interview is expected to take 30 minutes of your time and will be conducted in a quiet and private area.

Climate change is a long-term concern and the effects are already being experienced. Many studies have been conducted that indicate human health will be affected by the changes. With the many challenges we face with regards to healthcare and health promotion, awareness and preparedness must start sooner to evoke a curative outcome.

General instructions

1. Please provide as much of the requested information as possible. If data is requested and this is not available kindly indicate this.
2. If a question relates to an unfamiliar sector please indicate *I don't know* or leave it blank.
3. No answer is right or wrong.
4. Please do not use acronyms but spell out the full words or names of organisations.
5. Kindly provide copies of documents that may have relevance to a question.
6. The completed questionnaire must be placed in the envelope and handed to the interviewer.
7. If you need assistance, please feel free to ask the interviewer.

Thank you for taking the time to read through this and for agreeing to participate in this study.

APPENDIX E: QUESTIONNAIRES

QUESTIONNAIRE ON CLIMATE CHANGE, INFECTIOUS DISEASES AND PRIMARY HEALTHCARE IN SOUTH AFRICA

2013

GENERAL INSTRUCTIONS

Thank you for completing this questionnaire.

8. Please provide as much of the requested information as possible. If data is requested and this is not available kindly indicate this.
9. If a question relates to an unfamiliar sector please indicate *I don't know* or leave it blank.
10. No answer is right or wrong.
11. Please do not use acronyms but spell out the full words or names of organisations.
12. Kindly provide copies of documents that may have relevance to a question.
13. The completed questionnaire must be placed in the envelope and handed to the interviewer.
14. If you need assistance, please feel free to ask the interviewer.

The questionnaire is divided into four sections each relating to a particular aspect of the research study:

SECTION A: CLIMATE CHANGE

SECTION B: CLIMATE CHANGE AND HUMAN HEALTH

SECTION C: PRIMARY HEALTHCARE

SECTION D: GENERAL INFORMATION ABOUT THE CLINIC

SECTION A: CLIMATE CHANGE

Please state whether you tend to agree or disagree with the following statements:

	Strongly Agree	Agree	I don't know	Disagree	Strongly disagree
1. Our climate is changing					
2. Our weather is changing					
3. Climate and weather are the same					
4. Days are warmer because of ozone depletion					
5. Global warming is because of ozone depletion					
6. Global warming is caused by human activities					
7. The greenhouse gas effect is causing global warming					
8. Increased levels of carbon dioxide in the air are because of human activities					
9. Climate involves rainfall					
10. Climate change can affect human health					

SECTION B: THE EFFECT OF CLIMATE CHANGE ON HUMAN HEALTH

Please state whether you tend to agree or disagree with the following statements:

	Strongly Agree	Agree	I don't know	Disagree	Strongly disagree
1. Diseases are influenced by changes in the weather					
2. Diseases carried by insects will increase if the Earth's climate changes					
3. Diseases carried by insects are called vector-borne diseases					
4. Disease carried by water are called water-borne diseases					
5. Vector-borne and water-borne diseases are infectious					
6. Infectious diseases can travel with people					
7. Zoonosis is a disease passed from an animal to a human					
8. Tropical diseases prefer warm and wet climates					
9. Malaria is a tropical disease					
10. Malaria is a threat to public health					

SECTION C: PRIMARY HEALTHCARE

Please state whether you tend to agree or disagree with the following statements:

	Strongly Agree	Agree	I don't know	Disagree	Strongly disagree
1. There are sufficient resources to assist with the job					
2. Patients are referred if we are unable to assist					
3. There are changes in diseases we see					
4. There is an organisation monitoring these changes					
5. More is needed to improve primary healthcare					

SECTION D: GENERAL INFORMATION ABOUT THE CLINIC

1. How many patients are seen at the clinic per day?

0 - 20		1
21 - 40		2
41 - 60		3
61 - 80		4
80 plus		5

2. Are the patients mainly male ☐ or female ☐ or equal ☐

3. Into which age group do the majority of the patients fit?

0 - 3 years		1
4 - 10 years		2
11 - 17 years		3
18 - 25 years		4
26 - 35 years		5
36 - 45 years		6
46 - 55 years		7
55 - 65 years		8
65 years and older		9

4. What is the most common condition treated and what is the least common condition treated?

Most common	
Least common	

5. Please select from the options below which climate best fits your area:

Hot and wet	
Hot and dry	
Hot, Dry and Humid	
Warm and wet	
Warm and dry	
Windy and Dry	
Windy and Wet	
Hot, Humid and Wet	

6. What, in your opinion, is the greatest threat to the people in your area?

Water stress		1
Food shortages		2
Poor sanitation		3
Diseases such as malaria and cholera		4

Diseases such as diabetes or hypertension		5
---	--	---

7. How far do most of the people in your area have to travel to get to the clinic?

Up to 1 kilometre		1
Up to 2 kilometres		2
Up to 3 kilometres		3
Greater than 4 kilometres		4

15. How many people work in the clinic?

Professional staff		Admin staff	
--------------------	--	-------------	--

THANK YOU COMPLETING THIS QUESTIONNAIRE